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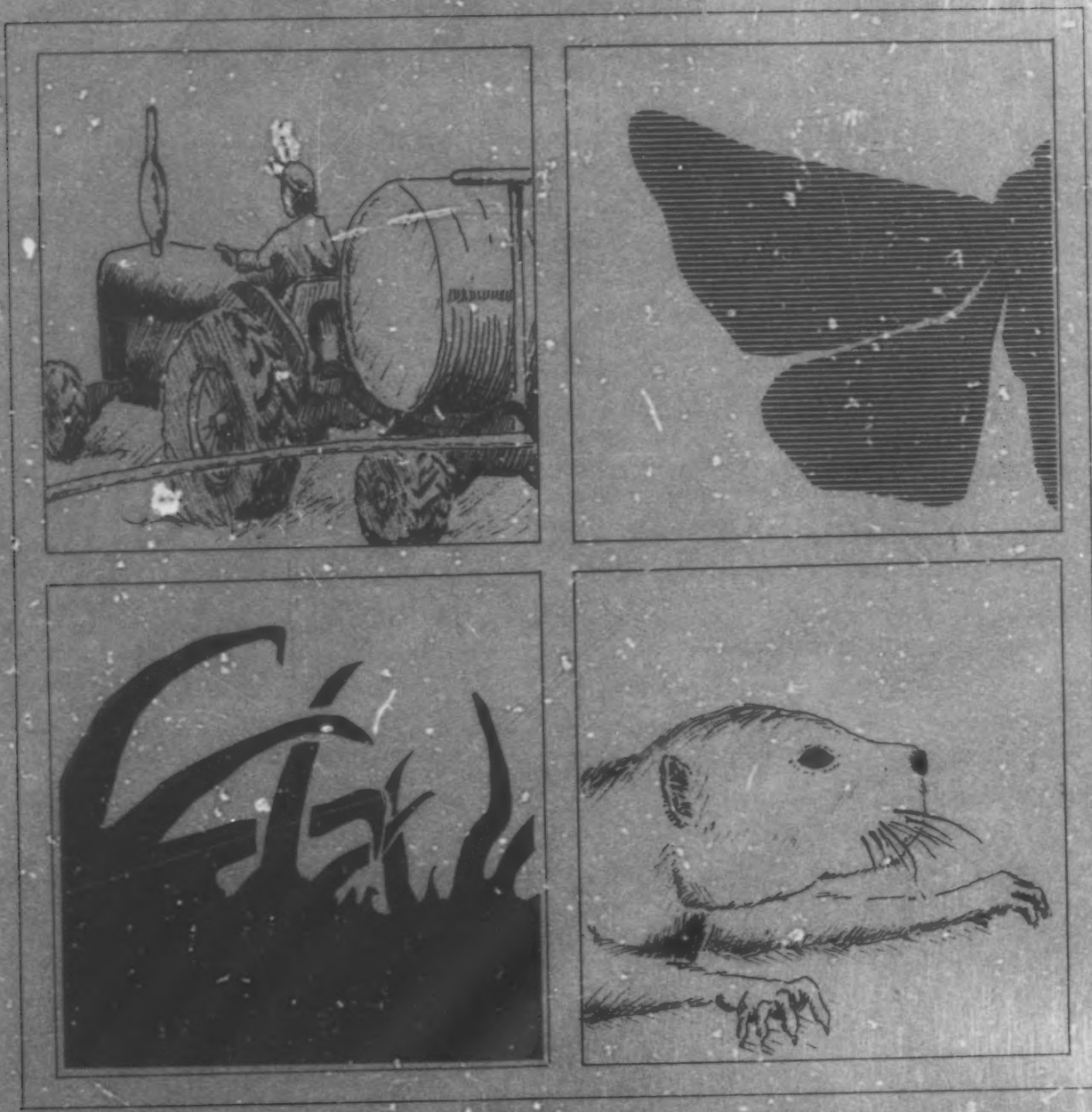
PRIVATE PESTICIDE APPLICATOR'S TRAINING MANUAL



U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII February 1989

EP1.8:

INTRODUCTION

The amended Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) contains a number of provisions designed to improve the control of pesticide use in terms of the environment and man while at the same time assuring that pesticides can continue to be available.

The amended FIFRA requires the Environmental Protection Agency (EPA) to classify all pesticide uses as either restricted use or general use, The FIFRA further requires that only certified applicators or applicators under the direct supervision of a certified applicator can apply pesticides classified for restricted use.

A pesticide product is designated as restricted use by EPA when it is felt that it may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator. Restricted use classification is an alternative to the cancellation of certain pesticides. The certification program is designed to ensure that users of Restricted Use pesticides are properly qualified to handle and use these materials in a safe and efficient manner.

Few would deny that pesticides are a vital tool for modern agriculture. However, there is increasing awareness among the general public concerning pesticides and problems associated with their use and misuse. Some of the concern is justified, some perhaps not. Regardless, the continued uses of pesticides rely heavily on the commitment of users to prevent harmful effects.

This manual is designed to help ensure that private pesticide applicators use pesticides properly and that you, your neighbor and the environment are adequately protected. It is meant for your benefit and for the benefit of agriculture. Improper use by a few is enough to deny the present benefits of pesticides to all.

This manual is not designed as an endorsement of pesticides. Indeed, other methods of control, and particularly the implementation of integrated pest management (IPM) programs, are strongly encouraged. Pesticides and their use are, however, the main concern of this manual.

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LAWS AND REGULATIONS

Various Federal and State laws and regulations affect the manufacture, labelling, use, storage, and handling of pesticides. Many of these laws are designed to insure the safety and effectiveness of pesticides by setting registration standards. Other laws also regulate uses of pesticides so that they can be used in ways that minimize harmful effects to humans, wildlife, and other organisms.

FIFRA

The most important pesticide law is the **Federal Insecticide, Fungicide, and Rodenticide Act** (**FIFRA**). FIFRA originally (1910) set standards for labelling of pesticides. Since that time this law has been updated and amended to its current form.

Various penalties can be invoked for violations of the Federal Insecticide, Fungicide and Rodenticide Act. For private applicators, civil penalties of up to $1,000 per offense may be assessed following a warning letter. Commercial applicators may receive civil penalties up to $5,000 for each violation. Violations can also result in criminal penalties of as much as $25,000 and 1 year in jail.

Restricted Use/ General Use

An important part of the present law is the classification of pesticides into either of two uses: Restricted Use or General Use. Whether an insecticide is classified as restricted or general use determines who may purchase and apply the pesticide. Labels of Restricted Use Pesticides contain the statement:

RESTRICTED USE PESTICIDE
For retail sale to and use by Certified Applicators or persons under the direct supervision and only for those uses covered by the Certified Applicator's certification.

The Administrator of the Environmental Protection Agency determines if pesticides are to be classified as Restricted or General Use. The decision to classify a Restricted Use pesticide is based on a finding that substantial adverse effects to the applicator or environment may occur without additional regulatory restrictions. Pesticides may also be classified as being Restricted Use if unreasonable harm to man or the environment may occur even if the pesticide is used as directed on label instructions. However, it is important to remember that all pesticides, Restricted or General Use alike, must be handled in a safe manner to minimize adverse effects.

Prior to the enactment of laws establishing restricted use classifications, the only available legal action to

the EPA against a pesticide with demonstrated environmental effects was to ban it. Restricted use regulation permits the continued use of many pesticides which might otherwise be subject to cancellation.

When considering whether or not to classify a pesticide for restricted use, the EPA takes into account: 1) accident history associated with the pesticide; 2) the known acute (short-term) or chronic (long-term) toxicity of the pesticide; and 3) the hazards associated with the pesticide to non-target species.

When reviewing the accident history of a pesticide, a review is made of all available information on the past use of the pesticide, including accident information. Research data from the manufacturer, independent research from private companies, as well as from Cooperative Extension personnel are included in this review. State regulatory agencies, wildlife agencies, and poison centers are also contacted. Data collected are analyzed to determine if any patterns of hazard have be associated with use of the product.

The toxicity of the pesticide to humans is a fundamental consideration in determining restricted use classifications. Highly toxic pesticides pose special risks to an applicator or farm worker and these increased risks often are sufficient to require special training for the applicator. Assessment of toxicity may also consider hazards associated with long-term exposure such as health problems (including cancer), reproductive disorders, and allergenic potential.

Non-target effects are hazards associated with use of the pesticide against species not directly targeted by application of the pesticide. For example, highly persistent pesticides, pesticides that move into water, or pesticides which are concentrated in wildlife, are types of hazards that are given special regulatory attention.

Active ingredients of some commonly used agricultural pesticides that currently (1988) are Restricted Use include:

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aldicarb (Temik)	aluminum phosphide
amitraz (Baam)	azinphosmethyl (Guthion)
brodifacoum (Talon)	carbofuran (Furadan)
chlorophacinone (Rozol)	chloropicrin (Chlor-O-Pic)
creosote	cyanazine (Bladex)
cycloheximide	cypermethrin (Ammo, Cymbush)

Some Restricted Use pesticides, continued:

diallate (Avadex)	diclofop methyl (Hoelon)
disulfoton (DiSyston)	esfenvalerate (Asana)
ethion	ethoprop (Mocap)
ethyl parathion	fenamiphos (Nemacur)
fenvalerate (Pydrin)	fonfos (Dyfonate)
lindane	methamidophos (Monitor)
methiocarb (Mesurol)	methomyl (Lannate)
methyl bromide	methyl parathion
mevinphos (Phosdrin)	nicotine
oxamyl (Vydate)	Metasystox-R
paraquat (Gramoxone)	pentachlorophenol
permethrin (Pounce, Ambush)	phorate (Thimet, Rampart)
picloram (Tordon)	phosphamidon (Swat)
sodium arsenate	pronamide (Kerb)
terbufos (Counter)	strychnine
	zinc phosphide

Additional pesticides may be classified as Restricted Use as they are reviewed for registration or when new information indicates a high degree of hazard associated with the pesticide. Information on current status of pesticide registrations is available from Cooperative Extension, the Colorado Department of Agriculture, and the Environmental Protection Agency.

However, pesticides may also be classified based on the percentage of the active ingredient, how it is formulated, or where it may be applied. For example, concentrated formulations of highly toxic pesticides are typically classified as restricted use whereas low percentage granules or wettable powders of the same active ingredient may be general use. Similarly, pesticides labelled for agricultural uses may be classified differently for the same purpose in a more sensitive environment (indoors, around livestock, near water, forests, etc.).

Private/ Commercial Applicators

Under the FIFRA regulations two types of pesticide applicators are recognized: private and commercial. A private applicator is a person who uses or supervises the use of restricted use pesticides in the production of agricultural commodities on land owned or rented by him or his employer. Farmers, ranchers, orchardists and greenhouse operators are common private applicators of pesticides in Colorado. A private applicator may also apply restricted use pesticides in production of agricultural commodities on the property of another person, if the pesticides are applied without

compensation. Trading of personal services as a form of compensation are exempted under this regulation. In Colorado, a grower/rancher is certified as a private applicator following completion of a question/answer form dealing with pesticide use information. Private applicator training in Colorado is administered by the Environmental Protection Agency (EPA). This manual is designed to provide training for private applicator certification in Colorado.

A commercial applicator is a person who uses or supervises the use of restricted use pesticides and is not a private applicator. Common commercial applicator groups in Colorado include agricultural pilots, landscape maintenance professionals, ditch and power company employees, government workers, grain elevator operators, and other applicators who apply pesticides as a condition of their employment. Pesticide applications made to agricultural commodities that have entered commercial channels and are no longer in production are also considered commercial applications. Licensing of commercial applicators is a responsibility of the Colorado State Department of Agriculture.

Endangered Species Act

Other laws and regulations also affect private pesticide applicators. The **Endangered Species Act**, designed to protect animal and plant species threatened or endangered with extinction, affects certain pesticide use practices in areas of Colorado where endangered species occur.

SARA/ EPCRA

The recent **Superfund Amendments and Reauthorization Act** (**SARA**) creates new regulations for the storage of pesticides and for handling pesticide spills. One section of this law, the **Emergency Planning and Community Right-to-Know Act** (**EPCRA**), requires that storages of certain pesticides exceeding minimum amounts must be reported to local and state authorities to assist in handling accidents that happen at such storages. This law also sets requirements for reporting pesticide spills. It is important that pesticide users become familiar with these new laws. Failure to comply with the reporting requirements may result in court injunction or fines of up to $25,000 for each day the violation continues. The regulations of this law are also developed by the Environmental Protection Agency. The program is being administered by the Hazardous Materials and Waste Management Division of the Colorado Department of Health.

Hazard Communications Standards

The **Hazard Communications Standards** (HCS) are proposals which requires that employers which employ more than 10 employees, permanently or part-time, develop a system to communicate to workers the hazards associated with the handling of and exposure to various chemicals, including pesticides. Certain training and supervision requirements are included in the proposed regulations. Industry employers which have one or more employees (part or full time) which may be exposed to hazardous materials fall under the guidelines of the Hazard Communications Standards. This includes Commercial Applicators (licensed by the Colorado Department of Agriculture), non-farm applicators, and other workers who may be exposed incidentally to hazardous materials. Farmers with 10 or fewer employees (including temporary labor) are exempt by the standards but larger farm employers are covered. Most private applicators engaged in the production of agricultural crops also are not regulated by the Hazard Communications Standards. However if a temporary labor camp is established and/or 10 or more employees are employed, as exists with many greenhouse operations, then this regulation also applies to private applicators. The Hazard Communications Standards to be administered by the Occupational Safety and Health Administration (OSHA).

Direct supervision

Recently, the Environmental Protection Agency set forth guidelines as to what responsibilities are associated with the "direct supervision" of non-certified applicators that apply Restricted Use pesticides. Under these rules, the certified applicator is responsible for ensuring the safe and effective use of any pesticide used under his direct supervison. Accordingly, the certified applicator is subject to enforcement liability for violations that are committed by a non-certified applicator who is operating "under his direct supervision".

PESTICIDE LABELS

The pesticide label is the information printed on or attached to the pesticide container. This label provides various types of discriptive information about the pesticide. Labels also include instructions on proper use of the product. These use instructions are the legal uses for the pesticide. The label is a legally binding document that must be followed explicitly. **Use of a pesticide in a manner that is inconsistent with the label instructions is a violation of the Federal Insecticide, Fungicide, and Rodenticide Act** (FIFRA).

The labeling of a pesticide is more inclusive and involves the information on the actual label plus all additional product information. This includes brochures, flyers, handouts, and advertising materials distributed by the manufacturer or dealer. These materials may not differ in meaning from the information involved in the pesticide registration.

LABEL CONTENT

FIFRA requires that all pesticide labels must contain the following information:

1. Brand name, common name, and chemical name;
2. Use classification;
3. Ingredient statement;
4. Registered uses;
5. Directions for use:
6. Safety information, signal words and precautions;
7. Net contents;
8. Name and address of manufacturer or registrant;
9. EPA registration number and establishment number.

BRAND NAME

The brand name is the product name given to the pesticide formulation by the manufacturer or distributor of the pesticide. The brand name is used for advertising and identification of various pesticide formulations. Several different brand name products may be identical or almost identical in their formulation. Furthermore, the brand name can be an unreliable means of identifying the active ingredients of the pesticide since manufacturers sometimes change the ingredients in brand named pesticides. Regardless of the different brand names, the pesticide must always be used in a manner that is consistent with the use instructions on the label.

COMMON NAME

The approved common name is a shortened generic name of the pesticide active ingredients. For example, copper hydroxide is the common name for the bacteriacide sold under brands names such as Champion, Blue Shield, and Kocide; the insecticide phorate is currently sold in Colorado under brand names including Thimet, Rampart, and Phorate; benomyl is the common name for the fungicide

most often sold under the Benlate brand name. Because so many different brand named products may be sold which contain the same active ingredient, university recommendations for insect control may list just the common names of the pesticides.

CHEMICAL NAME

The chemical name of the pesticide is the accepted description of the chemical composition and structure of the active pesticide ingredient. Often these seem rather complicated sounding but they are based on standard descriptions used by chemists. For example, 1 naphthyl-N-methyl-carbamate is the chemical name for the insecticide with the common name carbaryl, found in such brand name products as Sevin and Sevimol. 2,4-bis (isopropylamino)-6-methoxy-s-triazine is the chemical name for the herbicide prometon, sold under brand names such as Pramitol.

USE CLASSIFICATION

The use classification statement is required on the front panel of all pesticides that have been classified as being Restricted Use Pesticides. These pesticides have the statement:

"RESTRICTED USE PESTICIDE

For retail sale to and use by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicators certification".

In addition, there is often a statement indicating why the pesticide is classified as being restricted use. For example, warnings such as "Acute Oral and Dermal Toxicity" or "Avian Hazard" are commonly included with the use classification statement.

General use pesticides do not contain label classification statements.

INGREDIENT STATEMENT

The ingredient statement is also found in the front panel of the pesticide label. The ingredient statement contains the percentage of active ingredients found in the formulated pesticide. This typically follows the chemical name of the pesticide. For pesticides in liquid formulations (emulsifiable concentrates, flowables, etc.) a label statement usually follows that indicates the pounds of active ingredient found in a gallon of the formulated pesticide. Indications of the concentration of active ingredients may sometimes be found in the brand name of the pesticide. For example Benlate 50W is a wettable powder containing the active ingredient benomyl in a 50% concentration. Methyl Parathion 4E contains 4 pounds of methyl parathion per gallon of formulation.

Restricted Use Pesticide

For retail sale to and use ONLY by certified applicators or persons under the direct supervision of a certified applicator.

Contents: 50 Pounds
Active Ingredients.....25.0%

(arthrodie) 1,2,3-benzylchlorofluoromethane.....21.0%

(arthrobury) 1,2,3-benzylchlorofluoroethane.....4.0%

Inert Ingredients.....75.0%

Arthrohistory® Insecticide (25WP)- A wettable powder insecticide for control of insects on corn, wheat, strawberries and greenhouse-grown roses.

Always read and follow label directions
R=registered trademark of Arthohistory Co.

EPA Reg. No. XXXXXXX
EPA Est. No. YYYYYYY

Danger-Poison

Keep out of reach of children

¡Peligro!

Precaucion al usario: Si usted no lee ingles, no use este producto hasta que la etiqueta le haya sido explicada ampliamente.

For PRODUCT use information call 1-800-555-3456
For EMERGENCY information ONLY call 24 hours a day 1-800-555-6789.

Sample front panel of a pesticide label

Precautionary Statements Hazards to Humans and Domestic Animals

Danger!

Fatal if swallowed, inhaled, or absorbed through the skin. Do not breathe. Do not get in eyes, on skin, or on clothing.

Signs and symptoms of exposure-Vomiting, headache, difficulty breathing, pinpoint eye pupils. **IN ALL CASES OF SUSPECTED POISONING CONTACT A PHYSICIAN!**

Note to Physician- Arthrohistory insecticide is a cholinesterase inhibitor. Atropine sulfate is an effective antidote. If ingested, induce vomiting promptly.

Wear freshly laundered, long-sleeved work clothing. While transfering from package to equipment, wear a clean cap, rubber gloves, and goggles. Rubber gloves should be washed with soap and water after each use. Do not wear the same gloves for other work.

Do Not Breathe Dust

Wear a face mask or other respiratory equipment while emptying bags of product into a hopper. While emptying bags into equipment, pour downwind and allow as little free fall as possible. Do not pour at face level and do not allow dust to reach the breathing zone.

Do Not Contaminate Food or Feed Products

Once a bag has been opened, use it completely. Make sure the hoppers are emptied completely while still in field.

WARRANTY

USE ONLY ACCORDING TO LABEL DIRECTIONS

Arthrohistory Co. guarantees this product conforms to the description on this label. It is suited for the purpose sold when used according to directions. The buyer agrees to assume all risks in the case of damage from the use of this product.

DO NOT EXPOSE TO MOISTURE!

Directions for Use: It is in violation of federal law to use this product in a manner that is inconsistant with its labeling.

How much to apply-

Crop	Pest	Lbs/100 gal	Days Between Last Application and Harvest
Corn	European Corn Borer Corn earworm	1 1/2-2	10 Do not make more than 3 applications per season
	Aphids Grasshoppers	1/2-1	
Wheat	Aphids	1-2	15 Do not graze treated fields
	Grasshoppers Cutworms	2-3	
Strawberries	Aphids Spider mites Plant bugs	1-2	3 Do not apply when temperatures are below 50 degrees (F) or injury may result
Roses	Aphids Thrips Spider mites	3-5	2 Do not apply to hybrid tea roses or injury may result

Arthrohistory Insecticide Co.
P.O. Box 666
Yellow Jacket, Colorado USA

Sample side panels of a pesticide label

The remainder of the formulated pesticide is described as inert ingredients. The inert ingredients can contain various diluents or adjuvants used to aid in the function of active pesticide ingredient. Emulsifiers, spreaders, stickers, and buffering agents are examples of adjuvants. Some inert ingredients can have hazardous properties, occasionally exceeding the hazards associated with the main ingredient.

REGISTERED USES

The registered uses of the pesticide are usually found under a "DIRECTIONS FOR USE" statement on the pesticide label. These indicate the specific crops, livestock applications, or other registered use sites for the pesticide. It is illegal to use any pesticide at a site not on the pesticide label.

The directions for use also indicate how much of the pesticide to use, as well as when, where and how to apply the pesticide. Limitations attached to the use of the pesticide may also be found in this section or in a separate statement. Examples of limitations include preharvest intervals, reentry intervals, maximum numbers of applications, and geographic restrictions.

SIGNAL WORDS

Various warnings and precautions may be found throughout the label. On the front panel of all pesticides will be certain signal words that indicate the toxicity and/or hazards associated with use of the pesticide. Those pesticides of greatest hazard potential (Hazard Category I) will have labels containing the signal words **DANGER-POISON** and have a red skull and crossbones. Moderately hazardous pesticides (Hazard Category II) have the signal word **WARNING.** Less hazardous pesticides (Hazard Category III) have the signal word **CAUTION.** All pesticide labels must also contain the instructions **KEEP OUT OF REACH OF CHILDREN.** The approximate toxicity to humans of pesticides containing these signal words is:

Signal Word	Toxicity Category	Approximate oral* dose lethal to a human
DANGER-POISON (Skull/crossbones)	I-Highly toxic	Taste-teaspoon
WARNING	II-Moderately toxic	Teaspoon-2 tablespoons
CAUTION	III-Slightly toxic	Ounce or greater

* Signal words may also be based on dermal toxicity or other hazards associated with the pesticide.

The CAUTION signal word is also required on all pesticides classified as being relatively non-toxic, where a lethal oral dose would typically exceed a pint.

NET CONTENTS

The net contents indicate the amount of formulated pesticide in the package. This information is useful for determining the amount of pesticide to purchase.

REGISTRATION NUMBER

An EPA registration number is assigned to all pesticide formulations registered with the Environmental Protection Agency. Also included on the label is an establishment number to identify the place of manufacture. The address of the manufacturer is also included on pesticide labels.

USE INCONSISTENT WITH LABELING

The original wording of FIFRA prohibiting use of "any registered pesticide in a manner inconsistent with its labeling" was modified slightly in 1978 (Sec. 2(ee)) to allow some deviations from the label. Specifically there are four exceptions which allow applicators to deviate from label directions:

1. Application of pesticides at dosages, concentrations, or frequencies less than that specified on the label (i.e., using less than labelled rates);

2. Application of the pesticide against target pests not specified on the label if the crop, animal, or site is specified on the label (unless such uses are prohibited by label instructions);

3. Employment of application methods not prohibited by the label instructions. (Note: More recent regulations require that certain types of applications, such as chemigation, now require specific statements allowing use of these application methods);

4. Mixtures of pesticides and pesticide-fertilizer mixtures if not prohibited by the label instructions.

PESTS

In producing crops and livestock various organisms may compete with the grower/rancher. These organisms are defined as "pests", a human-oriented term that includes any plants, animals, or microorganisms that conflict with crop and livestock production, affect human health or comfort, or destroy property.

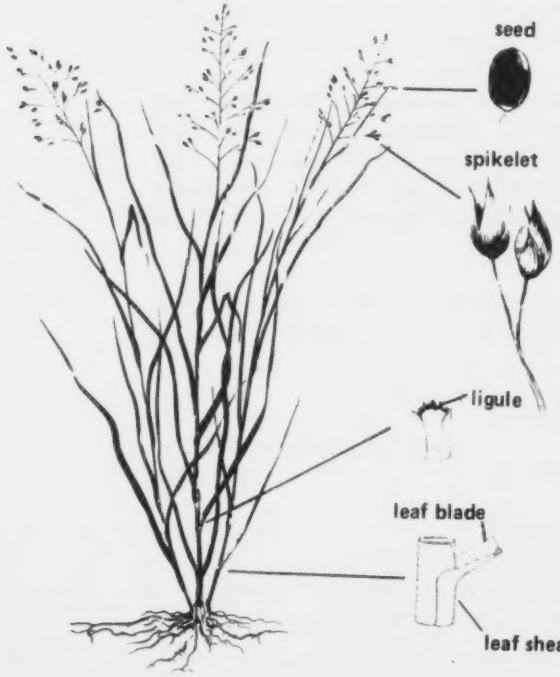
Since the most important first step in managing pest problems is proper identification, it is necessary to identify the pest problem. After proper identification, it is then important to recognize important aspects of the pest's behavior, growth, and damage potential so that it can be most effectively managed. Broadly speaking, common pests in Colorado can be put into 5 main groups:

Weeds;
Plant disease agents (fungi, bacteria, viruses, etc.);
Arthropods (insects, mites, ticks, etc.);
Slugs and snails;
Vertebrates (rodents, birds, predators, etc.).

WEEDS

Weeds are defined as being "plants out of place". Because the definition is based upon where a weed occurs it is sometimes difficult to distinguish between weed species and desirable plants. For example, even a widely recognized agricultural weed such as quackgrass is a beneficial species if it occurs on a steep road bank and assists in erosion control. Conversely, corn can be a weed if it occurs as a "volunteer" plant in a crop the following season.

Wild proso millet (*Panicum miliaceum L.*).



Most commonly, problem weeds occur in agricultural crops where they compete for water, nutrients, and light with the crop. Some weeds even secrete chemical inhibitors from their roots that damage nearby growing plants. Weeds may also foul harvest machinery or contaminate produce. In rangeland, weeds occur that crowd out desirable forage or may even be toxic to livestock. Finally, weeds may be important if they harbor plant disease agents, insects or mites.

Weeds can be classified in several ways but most commonly they are discussed by the length of their life cycle. Using this method, weeds are often discussed as being **annuals** (one year life cycle),

biennials (two year life cycle), and **perennials** (multi year life cycle).

Annual weeds

Annual weeds are plants that germinate from seed, grow, flower, and produce new seed in less than a 12 month period. However, among the annual weeds a variety of life cycles can occur.

Summer annuals are plants that germinate in spring, flower and produce seed during summer, and die in summer or fall. Common summer annual weeds are sunflower, lambsquarter, nightshade, pigweed, wild oats, wild proso millet, and Russian thistle. Summer annual weeds tend to be greatest problems in spring seeded cultivated crops.

Winter annuals are plants that germinate in fall and overwinter as low growing plants that resume growth in the spring. Flowering of winter annual weeds occur in spring and seeds are produced shortly afterwards. Common winter annual weeds include tansy mustard, jointed goatgrass, and shepard's purse. Winter annual weeds tend to be most important in fall seeded crops and in semi-permanent crops such as alfalfa.

Biennial weeds

Plants that require two seasons to complete development, biennial weeds germinate in spring or early summer. During the first year they overwinter as a low growing plant (rosette) with a long taproot. The following year, plants resume growth and a flowering spike is produced in late spring or summer. After producing seed the plants die. Biennial weeds in the region include musk thistle, burdock, and mullein and primarily occur as pest problems in pastures.

Perennial weeds

Perennial weeds live for several years and problem infestations may persist indefinitely without controls. Many perennial weeds produce extensive root systems that allow the plants to resist destruction by tillage and other practices that only affect aboveground parts of the plants. Perennial weeds reproduce by seeds and many infestations originate in this manner. However, once established, most perennial weeds are capable of spreading by underground structures such as "runners" (spreading roots, stolons, rhizomes), bulbs, and tubers. Important perennial weeds include field bindweed, dandelion, Canada thistle, leafy spurge, and quackgrass.

PLANT DISEASE AGENTS

Plant disease is often defined as being any condition that disturbs the normal and optimal growth and function of a plant. Under this definition many important diseases of plants involve adverse

environmental conditions such as nutrient imbalances, excessive salinity, oxygen starvation of roots, air pollution, and damage by extreme temperatures. These non-parasitic or abiotic diseases are not caused by living organisms and are sometimes called non-infectious or physiological disorders.

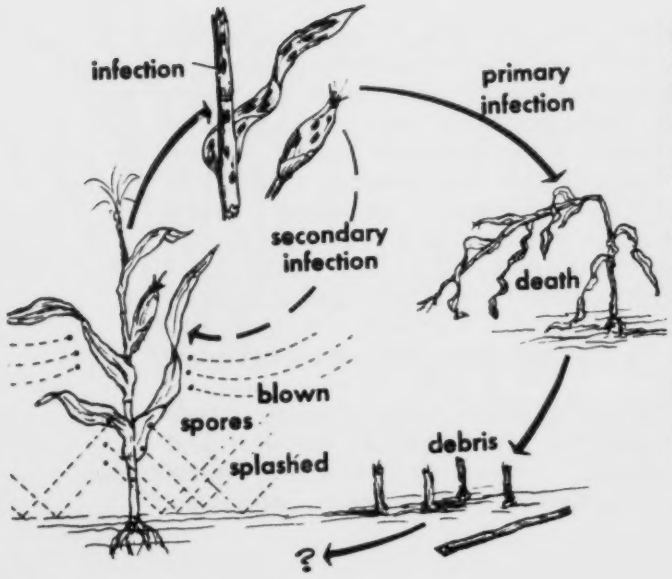
Parasitic diseases are those that are caused by infection of a plant by various types of microorganisms. Several different types of organisms can produce disease such as fungi, bacteria, mycoplasmas, viruses, and nematodes. Organisms which produce plant disease are known as plant pathogens.

Sometimes, plant disease agents are spread by other organisms, such as insects, mites, or nematodes. Organisms which spread disease are called vectors.

Fungi

Fungi are the most important single group of plant pathogens in Colorado. Many of these are familiar as the organisms involved in rotting/decay, mold, powdery mildew, vascular wilts, and leaf spotting disorders of plants. Stalk rot of corn, rusts, Fusarium wilt, Phythophthora root rot, botyrtis neck rot, early blight, damping off diseases, blue stain diseases of conifers, wood decay fungi, and storage molds are common examples of fungus diseases in Colorado.

Fungi reproduce primarily by spores. Tremendous numbers of spores may be released by a fungus that is actively growing and fruiting. For example the fine "dust" released by a mushroom can consist of millions of spores.



Spores are typically dispersed by blowing in the wind, although one kind of spore produced by the water molds (zoospores) can move on their own in water. If they land on a susceptible plant and conditions are favorable, usually when moisture and temperature are sufficient, the spores will germinate. During germination the spores produce specialized structures that help it to penetrate plant tissues and, if successful, the fungus will invade and infect the plant. Once within the plant the fungus grows by producing thread-like structures (mycelia).

Fungi are a highly diverse group of organisms with many different types of life cycles. Although many fungi can reproduce sexually, others (the Fungi Imperfecti) are only known to reproduce asexually, without producing separate male and female forms. Some plant pathogenic fungi can only survive on living plant tissues while others can continue to grow and reproduce even after these tissues have been killed. Other fungi live primarily on dead plants and only rarely invade healthy plants.

Several specialized structures may be formed by fungi. The familiar mushroom is the spore producing structure of many fungi while other organisms produce very small, often microscopic fruiting bodies. Many important fungi also can produce hardened protective structures, known as sclerotia, that allow the fungus to remain alive for several years in the soil.

Bacteria

Bacteria are very small, one-celled organisms. They reproduce by budding and are capable of rapidly increasing in numbers under favorable conditions. Those bacteria that are plant pathogens typically damage plants by dissolving plant tissues with enzymes secreted by the bacteria or by plugging the sap stream of the plant, causing it to wilt. Fire blight of apples and pears, bacterial ring rot, soft rots, crown gall, and halo blight of beans are common examples of bacterial diseases found in Colorado.

Bacteria have limited ability or are incapable of moving by themselves. Most spread of bacteria is therefore through splashing water, on infected seed, on farm equipment, and by transmission by insects. High moisture conditions are an important requirement for development of bacterial diseases.

Myco-plasmas

Mycoplasmas are a relatively recently discovered type of plant disease organism. They appear to share many characteristics with bacteria but lack a cell-wall. The mycoplasmas develop in the sap stream (phloem) of plants and all are spread by insects, primarily leafhoppers. Aster yellows is an important mycoplasma disease in Colorado that affects vegetable and flower crops. Pear decline and X-disease of peach are serious mycoplasma diseases of orchard crops.

Viruses

Viruses are extremely small particles that are primarily recognized by the symptoms they produce in plants. Leaf streaking diseases, "mosaics", many "yellows" diseases, and ring spots are common virus induced disease conditions in plants. Viruses do not

reproduce in a manner similar to other plant disease agents, but instead multiply by causing the infected cells of their host plant to form virus particles. By changing the normal function of the plant cells, the plant is injured. Many viruses are spread mechanically as plants rub together or as machinery moves between infected and healthy plants.

Other viruses are only spread by certain insects, usually aphids or leafhoppers. A few viruses are also spread by mites, nematodes, and even fungi. Potato leafroll, beet curly top, barley yellow dwarf, tomato spotted wilt, and wheat streak mosaic are among the more important virus diseases in Colorado which are spread by insects or related organisms.

Nematodes Nematodes are a type of animal sometimes known as a roundworm or eelworm. Most are microscopic in size and worm-like in general form. Thousands of different types of nematodes occur in healthy soils and water, but a few types of nematodes are known to attack plants and cause disease. Nematodes are capable of short distance movement on water films. However, most nematode problems originate in a field by human movement of infested soil or plant materials. This is particularly common with nematodes that produce resistant structures, such as cysts, that can allow them to survive for several years. Nematode problems are fairly rare in the arid West due to unfavorable conditions of drying and heavy soils. However, problems sometimes occur with the sugarbeet cyst nematode, alfalfa stem nematode, and various "cyst" and "sting" nematodes.

Parasitic plants Some plants live and develop by invading other plants and robbing these hosts of water and nutrients. Infected plants can be seriously damaged and even killed by this infection. Usually these parasitic plants do not produce green tissues that can allow their own production of food through photosynthesis. Dwarf mistletoe on various evergreen trees and dodder on alfalfa and other non-woody plants are the two most common parasitic plants in Colorado. These diseases spread by producing small seeds or, in the case of dodder, also by movement of plant fragments. Controls often require destruction of the infected host plants to prevent further development and spread of the parasitic plant.

ARTHROPODS Arthropods, or the "jointed foot" animals, are by far the most common form of life on earth. Among one group of arthropods alone, the insects, over 1.2 million different species have been described and new species are continuously being discovered. Add to this the other

common arthropods, such as the mites, ticks, spiders, millipedes, and centipedes, and the importance of the arthropods becomes even more impressive.

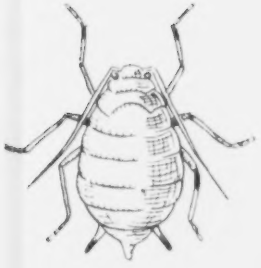
All of the arthropods are characterized by having a unique set of features that separates them from other animals. These include:

Segmented body;
Jointed appendages (legs, antennae, feet);
External skeleton (exoskeleton);
Growth involving periodic shedding and replacement of the exoskeleton (molting).

Arthropods also have characteristic internal structures such as a tube-like "heart" that runs down the back of the arthropod and a nerve cord that runs along the lower body.

Insects

The insects are the largest group of arthropods and can be identified by having certain additional characteristics that separate them from other arthropods:



3 body regions (head, thorax, abdomen);
3 pairs of legs;
Adult stage often winged.

The various groups of insects are then recognized by such features as types of wings, mouthparts, and developmental changes that the insects undergo.

Wing types vary greatly among the various adult insects. For example, the beetles have a hardened pair of front wings while moths and butterflies have wings covered with scales. Flies and mosquitoes are characterized by having only a single pair of wings in contrast to the two pairs found among most insects. Some groups of insects never produce wings.

Mouthparts of insects are generally designed to either cut and chew or to suck fluids.

Grasshoppers, beetles, caterpillars, bees, and wasps are typical of insects with chewing mouthparts. With these insects a hardened pair of mandibles, working sideways, is most important in grinding or cutting. A second set of mouthpart structures, the maxillae, also help to crush or manipulate the food. In some insects, such as the predatory green lacewings,

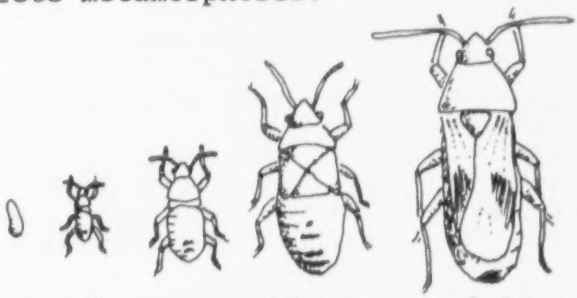
the mandibles and maxillae have been formed into a sickle shape to capture prey.

Insects with sucking mouthparts include aphids, leafhoppers, the "true" bugs, certain flies, moths, and the thrips. In most of these insects, the mandibles and the maxillae are greatly elongated and are designed to form a tube to penetrate plants or animals and suck fluids through a food channel running up the center of the mouthparts. Among the thrips, a special type of mouthpart occurs that involves puncturing tissues with a specialized type of mandible while sucking the fluids with a separate cone-like structure. Many of the insects that have sucking mouthparts are important pests since they can transmit disease organisms to plants or inject toxic substances during feeding.

Metamorphosis

All arthropods, including insects, also undergo changes in form as they grow and develop. This process is called **metamorphosis**. Among the insects, two patterns of metamorphosis predominate: simple (or gradual) metamorphosis and complete metamorphosis.

Simple metamorphosis of the chinch bug



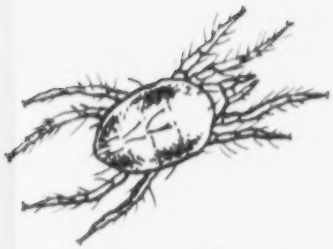
Aphids, leafhoppers, earwigs, grasshoppers, and true bugs are among the insects that undergo **simple metamorphosis**. Emerging from eggs, the immature stages of these insects are called nymphs. As the nymphs feed and grow they periodically shed their skins and transform to the next stage, a process known as molting. Typically, insects go through 3-7 molts before becoming full-grown. At the final molt they transform to the adult stage. Both nymphs and adults of insects with simple metamorphosis feed in the same manner, are often found together, and may somewhat resemble each other. However, adult insects often are winged and are sexually mature.

Moths, butterflies, beetles, flies, ants, and lacewings are among the many insects that undergo **complete metamorphosis**. Following egg hatch there occur immature stages called larvae. Often it is the larval stage of these insects that causes the most injury to plants or animals since they feed heavily in order to develop. As

they grow, the larvae molt and shed their skin repeatedly. After reaching full development, larvae shed their last larval skin and transform into a unique developmental stage, the pupa. Although insects in the pupal stage do not feed and appear to be inactive, dramatic changes in form occur which finally terminate in the adult stage. Among the insects with complete metamorphosis, larvae and adults often look strikingly different and often have very different feeding and behavioral habits.

Mites and ticks

The mites and ticks, along with the spiders and scorpions, are classified into a separate group of Arthropods, the arachnids. The key diagnostic characteristic of most arachnids is their 4 pairs of legs. Although most arachnids also have two distinctive body regions (cepahlothorax and abdomen) it is not very distinctive in the mites and tick which are generally rounded in body shape.



Mites and ticks produce eggs which hatch under favorable conditions. The newly emerged mite and tick, called a larva, is very small and has only 3 pairs of legs. After the first molt they acquire the typical fourth pair of legs and are called a nymph. There can be several nymphal stages before transformation to the adult mite or tick.

Arthropods as pests

Insects, mites, and ticks occur as pests of crops, livestock, in stored products, serve as transmitters of plant and animal disease and can interfere with our comfort. Annually, pest species of arthropods in the United States do damage in the billions of dollars and worldwide losses are often much greater.

However, many insects are also considered to be beneficial species since they assist in the pollination of our crops, recycle nutrients, serve as food for wildlife and other desirable species, and prey upon the pest species that do occur. It is therefore very important to distinguish the pest species that do occur in our region from those that are beneficial and also to separate them from the great majority of arthropods that are considered to be neither pest nor beneficial species.

SLUGS AND SNAILS

Slugs and snails are members of the group of animals classified as mollusks. As such, they are more closely related to organisms such as clams or mussels than to insects and other arthropods. Also, pesticides used to control arthropods have little effect on slugs and

snails.

Slugs and most snails require moist conditions to survive and develop. Because of this limitation, problems with pest species of slugs and snails are relatively infrequent in Colorado. However, problems can be severe in certain environments such as in greenhouses or in lush growing garden areas.

VERTEBRATE PESTS

Problems with vertebrate pests, mammals and birds, are important in some areas of the state. These include rodents as well as species that might normally be considered desirable "wildlife" except when they interfere with agricultural production. Examples include deer and elk damage to fruits and vegetables in the mountain areas, coyote predation of lambs, blackbird injury to ripening cherries, vole injury to trees, and rodent infestation of grain storages.

Control of vertebrate pests is complicated by both practical and legal considerations. The unpredictability and mobility of vertebrates often prevent them from being preventatively managed outside the crop. Control techniques suitable for vertebrate control are limited. Public perceptions of vertebrate control and the legally protected status of many vertebrates also prevent many control practices.

Vertebrate pest management often requires the use of several, non-pesticidal control approaches. Because of the complications in vertebrate management, it is desirable to contact local Cooperative Extension offices or Division of Wildlife offices for latest directions on managing area pest problems.

PEST MANAGEMENT TECHNIQUES

A variety of methods are available for managing pest problems and effective pest managment often requires the combined use of several techniques. These pest management approaches are broadly categorized as being biological, cultural, mechanical, chemical and regulatory/legal types of controls.

NATURAL AND BIOLOGICAL CONTROL

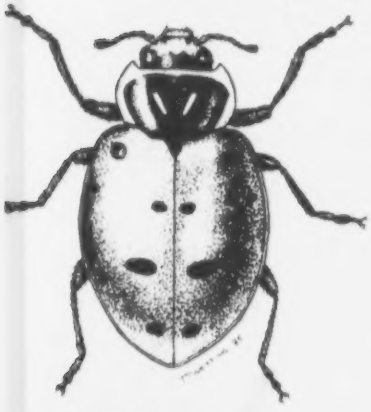
All pest species are controlled to some degree by natural control, sometimes referred to as the "balance of nature". These natural controls often prevent pest species from causing economic losses, although many pest species tend to be naturally controlled at levels which do not cause crop and livestock losses.

Many of the most important natural controls are abiotic controls that involve aspects of the physical environment such as temperature, moisture, and wind. For example, exposure to excessive (or erratic) cold winter temperatures is very important in limiting the overwintering survival of many insect and mite pests in Colorado. Weed seed germination is dependent on the occurrence of adequate conditions of soil moisture and temperature. Movement of bacteria, germination of fungus spores, and nematode survival are all highly dependent on the existence of water films. Blowing winds, and the accompanied movements of soil particles and splashing water drops, can be very destructive to insect populations.

Biotic controls involve various naturally occurring animals or disease agents that feed upon or infect pest species. These natural enemies of pest species are variously described as being predators, parasites, and pathogens.

Predators

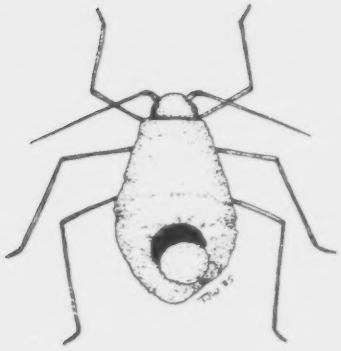
The term predator is defined somewhat differently when it describes natural enemies of insect and mite pests or when it describes biotic weed controls. An insect predator is usually an organism that is a free living hunter in its immature and adult stages. Insect predators feed upon several prey during its development. Ladybird beetles (ladybugs), lacewings, ground beetles, and damsel bugs are common insect predators in Colorado. A predator of weeds would be the various insects and mites which feed upon the plant and the seeds or storage tissues produced by the weed.



Ladybird beetle.

Parasites

Parasite is a term used to describe natural enemies of insects. Although the term often refers to organisms that are harmful to desirable plants, animals, and humans, when attacking pest species parasites are considered to be beneficial. Insect parasites consist of other insects which develop internally (rarely externally) upon a host insect. Only a single host insect is killed by a developing parasite and often several parasites develop in a single host insect. Parasitic insects are often highly specific as to the organism on which they can develop and many attack only a single species of insect or a small group of closely related insects. Parasitic wasps and tachinid flies are common insect parasites. Colorado potato beetle, forest tent caterpillar, and greenhouse whitefly are examples of local pests which can be largely controlled by parasites.



Parasitized aphid mummy

Pathogens

Pathogens are disease agents that affect pest species. These include various types of microorganisms such as fungi, bacteria, viruses, and nematodes. Weeds, insects, mites, and plant pathogens are all subject to attack by pathogens. Pathogens are usually very specific in the types of organisms that they can attack. Although the pathogens that infect pest species are somewhat similar to pathogens of desirable plants and animals, very few pathogens can attack both pest and desirable species. For example, none of the numerous fungus diseases affecting pest insects attack mammals or birds. Similarly, fungi which attack plant pathogenic fungi also do not attack desirable species of plants.

Biological control involves the manipulation of of biotic controls in pest management. This is achieved by various methods:

-introduction of natural enemies of pests into an area where the natural enemies did not previously exist;

-conservation of existing natural enemies of pests;

-improving the effectiveness of pest natural enemies by creating favorable environmental conditions for the natural enemies.

Several natural enemies have been introduced into Colorado, following the establishment of new pest species in the state. For example, several wasps that attack

alfalfa weevil are now widely established and help in reducing losses from this insect. Similarly, weevils (Rhynocyllus) that attack the seeds of musk thistle have been established in the region. New natural enemies of insect pests and weeds are continually being introduced into Colorado by programs administered by the Colorado Department of Agriculture.

Some natural enemies of pests are widely available for use as a sort of "biological pesticide". These types of biological controls are being pursued by several manufacturers. Current examples include the bacterial disease Bacillus thuringiensis, effective for control of most leaf and needle feeding caterpillars, such as the European corn borer. Other strains of this same disease control mosquito larvae in water or fungus gnats in potting mixes. Several species of predatory mites are sold for control of mites and thrips on greenhouse crops. Microorganisms against crown gall bacteria in woody plants have been very effective against this pest. Disease agents that attack specific weeds are actively being developed.

Biological controls are most easily conserved by pursuing chemical and cultural control practices that minimize damage to biotic controls. For example insecticides vary widely in their ability to kill natural enemies of pest insects and "selective" insecticides can improve the effectiveness of insect natural enemies. Pesticides may also be timed in a manner that makes them more selective; e.g., the use of dormant oils on fruit trees which spare insect predators and parasites that do not overwinter on trees. Reducing dusty conditions in a planting helps the effectiveness of many insect parasites and with predators of spider mites.

Improving the performance of natural enemies of pests often involves more sophisticated changes in crop environments. For example, many insect predators and parasites use nectar which increases their survival and egg production. Suitable nectar plants or applying artificial nectar sprays can help many insect predators, such as ladybird beetles and green lacewings, which feed on nectar.

CULTURAL CONTROLS

Production practices almost always have some impact on pest populations. When these practices are consciously employed, cultural controls can be among the most important means of managing pest problems. Among the several cultural control practices are:

Clean planting stock Weed seeds and many plant disease agents can easily be spread in seed or other planting materials. Use of high quality planting materials-and clean planting equipment-can prevent the establishment of serious pest problems in a field.

Resistant varieties Development and use of plant varieties that are resistant to certain crop diseases is widespread and essential to the production of many crops. Some insect resistant varieties also exist, such as pea aphid resistant alfalfa.

Plant vigor Cultural conditions that favor rapid stand establishment and vigorous plant growth often help to reduce pest problems. Weeds can be smothered by many crops after the crop has formed a thick canopy. Many fungus diseases only become important when crops are under some sort of stress due to inadequate watering, poor fertility, or some other cause.

Crop siting Properly locating a crop can greatly influence incidence of pest problems. Whenever possible, plantings should be made in fields which do not have histories of weed or disease problems that would affect the crop. Sometimes it is also possible to isolate fields from overwintering sources of insects and from diseases spread by insects, a common practice in seed potato production.

Crop rotation Crop rotation considerations are fundamental to managing problems with many plant diseases. Since many plant disease-producing organisms survive in crop debris within a field, rotation to non-susceptible crops can prevent further development of the disease organism and, ultimately, cause the disease agents to die-out. For many plant pathogenic organisms, such as soft rots and Botrytis, a single year of crop rotation can sufficiently reduce survival of plant disease agents so that they are not in sufficient numbers to cause problems. Other plant disease agents, such as white mold and sugar beet cyst nematodes, may require several year rotations out of susceptible crops to reduce the disease organism to non-damaging levels.

Crop rotations are important considerations in managing difficult weed problems. Densely growing crops, such as small grains, may be used to help smother developing weeds that have developed as problems in a field. Suitable crop rotations also allow control of weeds with herbicides that are not suitable in other crop systems. For example, wild proso millet may be better controlled with post emergence herbicides in bean plantings; available pre-emergent herbicides in corn may give lesser

levels of control.

Crop rotation is most effective for control of insects that overwinter in fields in immobile (egg, larva) stages. These insects are killed if rotational crops do not support later life stages of the insect. For example, corn rootworms lay eggs around the base of corn plants in late summer. If corn is not planted the next year within a few feet of the eggs, the larvae which hatch in June die from starvation. Rotation of greenhouse crops to allow for "host-free" periods can be an important means of managing greenhouse whitefly.

Sanitation

Proper sanitation practices are important in the overall management of several pest problems. For example, many pest species of flies that attack livestock breed on manure and proper manure handling is essential in reducing fly populations. Culled vegetables often serve as reservoirs for disease agents unless they are properly disposed. Pruning and disposal of diseased wood is important in management of fire blight. Flower cuttings and plant debris under benches can allow leafminers and fungus gnats to increase in greenhouses. Disinfection is important in control of bacterial ring rot of potatoes and equipment cleaning prevents spread of disease agents and weeds between fields.

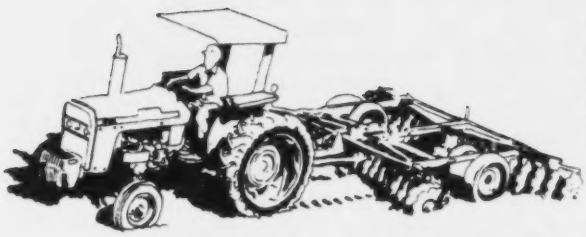
Harvest practices

Harvest practices can be very important in managing several pest problems. Bruising of potatoes or onions during harvest is an important source of wounding that allows plant disease agents to enter and to destroy the crop in storage. Incidence of blister beetle problems in alfalfa hay increases when the hay is crimped during cutting, trapping the beetles.

Tillage

Almost all tillage practices are primarily designed to aid in managing weed problems. Roots of weeds are cut during cultivation and young seedlings can be buried. Weed seeds are buried during plowing, although many can survive for several years and return to the surface in subsequent plowing. Elimination of surface debris is also important in properly using many preemergence herbicides that are sprayed as a soil barrier.

Tillage helps to hasten the decomposition of crop residues and can reduce survival of some plant disease agents. Many fungus disease organisms overwinter on intact crop debris but are killed when decomposition occurs. For example, tan spot of wheat becomes more prevalent under reduced tillage systems.



Effects of plowing on insect populations are mixed. Many insects which overwinter in crop debris, such as European corn borer, can be killed during plowing. Grasshopper eggs can be exposed and killed during tillage. Highly mobile species, such as potato psyllid and corn earworm, are not directly affected by tillage. However, landing of greenbug aphids has been shown to be reduced on wheat that has lighter surface backgrounds created by crop debris.

MECHANICAL CONTROLS

Mechanical controls involve the use of means to physically remove, trap, or exclude pest species. Often these controls are fairly labor intensive or expensive but can be useful in limited acreages, in crops of high value, or where alternative controls do not exist.

Various insect exclusionary devices are probably the most important kinds of mechanical pest controls. Screening dairy barns is important in reducing fly problems. Screens also prevent many insects, such as cutworms and thrips, from entering greenhouses. Slugs can be excluded from a planting by use of copper barriers. Insects may also be trapped by attracting them to lights and colors. Hand picking of insect pests off a crop would be a simple illustration of a mechanical control.

Mechanical control of weeds might involve hand pulling or hoeing. Mowing is another commonly practiced weed control. Artificial mulches may be considered mechanical weed controls. Burning of ditchbanks and selective flaming is also used to help manage weed problems.

REGULATORY CONTROLS

Legal controls involve the lawful regulation of areas to eradicate, prevent or control infestations of pest species.

<u>Quarantines</u> are laws that regulate the movement of articles in commerce to help prevent the spread of pest problems. If products move out of areas known to be infested by certain pests, they must be inspected and certified as being pest-free if they move into a protected area. Quarantines are very important in preventing the occurrence of many animal diseases in Colorado, such as foot and mouth disease and brucellosis. Quarantines have also affected the movement of uninspected apples into California that have originated from certain West Slope orchard areas where apple maggot infestations are suspected. Quarantines also exist

restricting the movement of white fleshed peaches and nectarines into Mesa County to prevent the introduction of peach mosaic disease.

Eradication programs are occasionally attempted to eliminate pest species shortly after they have entered a new area. A common insect against which eradication programs have been attempted in many areas, including Colorado, is the gypsy moth, a serious pest of shade trees. Eradication efforts are most successful if initiated shortly after a pest has entered a region so that its distribution is limited.

Pest control districts are often formed to help limit the spread of pests that occur over large areas and require a cooperative control effort throughout a region. Weed control districts, empowered by noxious weed laws, exist in many parts of Colorado focussing on weed species that are particularly injurious and difficult to control once established, such as Canada thistle and leafy spurge. The districts treat infested areas with herbicides and often have powers to require landowners to control noxious weeds on their properties. During periods of grasshopper outbreaks, grasshopper control districts can be formed to coordinate area-wide suppression activities.

CHEMICAL CONTROL

Chemical controls typically involve the use of pesticides. Use of pesticides has occurred over centuries but it has only been in the past 40 years that highly effective pesticides have been identified and widely used in crop and livestock protection. Pesticide use is central to the control of many pest problems at present but certain associated risks and hazards require that they be used with particular care. Pesticides are discussed more completely in the following chapter.

INTEGRATED PEST MANAGEMENT (IPM)

Often, a variety of control techniques is required to effectively manage pest problems. For example, management of flies in a dairy operation may require effective manure management (cultural control), screening of barns to exclude flies (mechanical control), and selective use of insecticides (chemical control). None of these techniques alone may be sufficiently effective.

Care must also be taken to coordinate these various control techniques so that their effects don't conflict in overall pest management. For example, certain uses of insecticides applied against pest species can seriously reduce the effectiveness of biological insect controls. Mulching used for weed control can increase problems with slugs, particularly when high moisture

conditions also occur. Tillage and harvest practices may affect beneficial biological control organisms as well as pests.

Effective pest management can often be reduced if single control approaches are repeatedly used. This has most commonly been documented with use of pesticides. Many insects, mites, fungi, and even a few weeds have become resistant to pesticides that formerly were effective. Pesticide use may also cause shifts in pest problems to occur. For example, nightshade weed problems have developed in many fields following use of several commonly used herbicides that were ineffective against nightshade. Mite problems in fruit and field corn often are aggravated by early season insecticide use directed against other pests.

Finally, other serious "non-target" effects may occur from pest management practices. Many pesticides are highly toxic to the applicator or to wildlife around a treated area. Pesticides may move into and pollute ground or surface waters. Pesticide residues may also contaminate food or feed. Plants may be inadvertently damaged by pesticides. These hidden costs from pest control practices are not always fully considered during pest control decision-making.

Integrated Pest Management (IPM) is a system for making the optimal pest management decisions based on both ecological and economic considerations. It is not a particularly new idea since sound pest management practice has always involved IPM approaches.

Fundamental to Integrated Pest Management are a number of assumptions:

-optimal pest management is achieved by a variety of techniques;

-pest management techniques should be used in a coordinated (integrated) manner so that their effects complement each other;

-since eradication of many pests is not often achievable nor desirable, controls should be applied only when pest populations are sufficient to justify their control. Scouting or monitoring pest populations is usually required;

-pest management techniques should consider the long-term costs of the practice, including the social and environmental costs;

-the performance of any pest management practice will be continually reevaluated to determine if it is achieving the desired result in the most effective manner.

Economic threshold

One concept that is basic to the Integrated Pest Management approach is the economic threshold. This recognizes that almost any pest can occur at levels that do not cause crop loss or at levels where the cost of control exceeds the damage cost. The lowest level of the insect that will cause economic damage is termed the economic injury level. The economic threshold is "the density at which control measures should be applied to prevent an increasing pest population from reaching the economic injury level".

Use of economic thresholds require that fields be regularly monitored or scouted to determine the size of the pest populations. Economic thesholds also change with the growth stage of the crop and the crop value.

Several economic thresholds exist for Colorado pests, particularly insect pests. For example, control of Banks grass mite on corn is recommended when visible damage occurs on the lower third of the plant and the mites have begun to make colonies on the middle third of the plant. Treatments for control of greenbug aphids on small grains are recommended when populations reach 5-15 aphids/stem on seedlings. The threshold increases to 25 per stem during the boot to heading stages. Greenbug control is not recommended for small grains that are heading since is is unlikely that there would be a net economic return from an insecticide application.

PESTICIDES

A pesticide is a chemical substance produced and sold for the control of a pest species. The ending of the term is derived from the Latin "cida", meaning "to kill", although some pesticides may merely inhibit the development of a pest rather than kill it. Chemicals used to repel or attract pest species may also be regulated as pesticides. In the current version of FIFRA law, the legal definition of a pesticide has further been expanded to include defoliants, plant growth regulators, and dessicants.

Various types of pesticides are recognized depending on the type of pest they are used to control. Common pesticides include:

Herbicide-a chemical substance sold to kill undesirable plants.
Insecticide-a chemical substance sold to kill undesirable insects.
Fungicide-a chemical substance sold to kill undesirable fungi.
Miticide (also called acaricide)-a chemical substance sold to kill mites and ticks.
Bacteriacide-a chemical substance sold to kill bacteria (sometimes referred to as sanitizers or disinfectants).
Molluscicide-a chemical substance sold to kill pest mollusks such as slugs and snails.
Nematicide-a chemical substance sold to kill nematodes.
Rodenticide-a chemical substance sold to kill rodents.
Plant growth regulator-a chemical substance used to desirably alter the growth processes of crop plants.
Wood preservative-a chemical substance used to protect wood from decay and stain fungi, insects, and other wood destroying organisms.
Defoliant-a chemical substance used to produce leaf drop.
Dessicant-a chemical substance used to promote drying as a harvest aid.

CLASSIFICATIONS OF PESTICIDES

Pesticides may be grouped and classified in a number of different ways based on their chemistry, origin, or mode of action and use.

Chemistry Pesticides and other chemical compounds are often discussed as having inorganic or organic chemistry. Organic compounds are those that contain carbon in their molecular structure. These are overwhelmingly the largest group of currently used pesticides. Inorganic pesticides do not contain carbon and are the oldest used pesticides. Copper fungicides, lime-sulfur used to control fungi and mites, boric acid used for cockroach control, and ammonium sulfamate herbicides are examples of inorganic pesticides.

Source Pesticides, particularly insecticides, are also discussed by their source of production. Natural organic pesticides are derived from natural sources. Various plant-derived insecticides, such as pyrethrum, rotenone, and nicotine are examples of natural organic pesticides. Synthetic organic pesticides are those which are produced by man-made manufacture. Almost all currently used pesticides are synthetically produced compounds, although some are based on naturally occurring chemicals.

Systemic/ contact Pesticides may also be classified as being systemic or non-systemic contact compounds. Applied to herbicides, the term translocated herbicide is sometimes used when they move systemically in a plant. Systemic pesticides used on plants are those which can be picked up through leaves and/or roots of plants and moved within the plant. Systemic pesticides vary in how readily they move in the plant and movement is dependent on environmental factors as well. However, some systemic pesticides move widely in plants. For example, glyphosate herbicide applied to leaves may move into and kill the plant roots. Alternatively, aldicarb insecticide applied to roots moves upwards in the plant and concentrates in actively growing foliage. Some insecticides used for control of livestock pests are also systemic after being fed or injected into an animal.

Mode of entry Special terms are used to describe insecticides by the means through which they enter the insect. Stomach poisons, such as Bacillus thuringiensis, must be ingested by the insect to be effective. Contact insecticides can penetrate through the external skeleton (cuticle) of the insect. Insecticides which primarily enter through the breathing openings (spiracles) are known as fumigants.

Herbicide terms Herbicides are often discussed as being selective or non-selective. Selective herbicides are ones which can be used to control one type of plant but cause little or no injury to another plant. For example, 2,4-D is generally considered to be selective since it is much more active against broadleaved weeds than against grasses. However, used at excessive rates or at the impropoer time, selectivity decreases and injury can also occur to normally tolerant desireable crops.

Many selective herbicides are applied to actively growing weeds and act as contact or translocated herbicides as described above. Others are applied to the soil. Preplant soil herbicide applications are made prior to planting a crop. Preemergence herbicide applications are made after planting but before weed or crop emergence. Postemergence applications are made

after weeds and the crop have emerged.

Non-selective herbicides are compounds that are toxic to both crop and weed species of plants. Dessicant herbicides such as paraquat and the translocated glyphosate are examples of non-selective herbicides sprayed onto plants. Soil sterilants are non-selective herbicides applied to soil which can kill actively growing plants and prevent growth of new plants for as long as the compound remains active, often several years. Soil sterilants are primarily used in maintaining rights-of-way or in areas where no vegetation is desired. Serious inadvertent injuries to desirable plants, such as trees and shrubs, have occurred from use of soil sterilants near landscape plantings.

Fungicide terms

Fungicides are often classified as being protectants or eradicants. Protectants, such as maneb and chlorothalonil, must be in place on the surface of the plant before fungal infection of the plant occurs. Eradicants, such as benomyl, can move within the plant and kill developing fungi.

Among the various kinds of pesticides, chemical families are recognized based upon similarities in chemical structure and pesticidal activity. Some of the common families of pesticides are discussed below:

FAMILIES OF HERBICIDES

Triazine

The triazine herbicides are used to kill weed seedlings. Atrazine, simazine, and cyanazine are commonly used members of this herbicide family. Plants are killed by triazine herbicides by interfering with photosynthesis used by the plants to produce food. Broadleaved weeds are particulary susceptible to these herbicides. Some triazine herbicides may persist for several months or even years and injure suceptible plants in following growing seasons. Some triazine herbicides have been found to leach into groundwater or to move laterally through the soil injuring desirable plants.

Phenoxy

The phenoxy herbicides are widely used in agriculture for control of broadleaf weeds. 2,4-D and MCPB are examples of phenoxy herbicides. This group of herbicides acts like many plant hormones and primarily affects the actively growing tissue of the plants. Most often these herbicides are sprayed onto plants, although they can also be picked up by plant roots. Phenoxy herbicides have often caused unwanted plant injuries following application during conditions favoring drift onto susceptible plants.

Acid amine

Acid amide herbicides are usually used to control seedling weeds prior to their emergence or immediately following emergence. Alachlor and propachlor are examples. Acid amide herbicides are absorbed into the shoot or root of plants affecting various growth processes in susceptible plants. Many broadleaved and grass weeds are susceptible to acid amide herbicides. Persistence of these herbicides is generally fairly short. However, many acid amide herbicides are susceptible to leaching and have been found contaminating groundwater.

Dinitro-aniline

Dinitroaniline herbicides are used to control germinating weeds. Trifluralin and oryzalin are examples of this family of herbicides. The dinitroaniline herbicides prevent cells in roots and shoots from dividing and developing. Many annual grass and broadleaved weeds are susceptible to these herbicides. Dinitroaniline herbicides are yellow in color and must be incorporated into the soil to provide weed control.

Thiocar-bamate

Thiocarbamate herbicides are used to control germinating seedlings and young weeds, primarily grasses. EPTC, cycloate, and butylate are examples. The thiocarbamate herbicides will change into a gas form (volatilize) readily when exposed to moisture and they often must be incorporated into the soil to maintain effective persistence. Thiocarbamate herbicides degrade rapidly in warm moist soils.

Sulfonyl urea

Sulfonyl urea herbicides are a fairly new group of herbicides with very diverse characteristics. At present most are being used in control of weeds on dry-land wheat. However, new compounds continue to be developed some of which can be used after weeds have germinated (post-emergence). The sulfonyl ureas are used at extremely low rates, sometimes less than an ounce per acre, but can be highly persistent in alkaline soils.

FAMILIES OF INSECTICIDES AND MITICIDES

Chlorinated hydro-carbon

Chlorinated hydrocarbon insecticides, such as DDT, toxaphene, and dieldrin were the predominantly used family of insecticides following their introduction after World War II. However, environmental and health related concerns have caused most of the chlorinated hydrocarbon insecticides to be discontinued or banned in recent years. Some were extremely persistent in the environment. Problems with many chlorinated hydrocarbons also involved their tendancy to concentrate in the fatty tissues of humans, livestock, and wildlife. This latter phenomena, called bio-accumulation, had severe effects

on many forms of wildlife. Remaining chlorinated hydrocarbon insecticides include methoxychlor, dicofol, and endosulfan. Chlorinated hydrocarbons tend to be more active at cool temperatures than at warm temperatures.

Organo-phosphate

Most chlorinated hydrocarbon insecticides were subsequently replaced by various insecticides in the organophosphate family. Parathion, disulfoton, phorate, and chlorpyrifos are examples. Some of these insecticides are systemic when applied to foliage or roots of plants; others are not. Organophosphate insecticides do not persist in the environment as long as the chlorinated hydrocarbon products but tend to be more toxic to applicators and wildlife. The organophosphate insecticides are nerve poisons which inhibit cholinesterase, used in transmission of nerve impulses. Effects on cholinesterase by the organophosphate insecticides are cumulative so repeated exposures result in increased poisoning. Most serious human pesticide poisonings have involved organophosphate insecticides.

Carbamate

Carbamate (or n-methyl carbamate) insecticides also are nerve poisons in insects and other animals, similar to the organophosphate insecticides. Carbaryl, methomyl, and aldicarb are examples of carbamate insecticides. However, effects of poisoning are more readily reversible (i.e., not cumulative) than with the organophosphates. Carbamates tend to be quite water soluble and some are systemic in plants. Because of their water solubility, several carbamates are susceptible to leaching.

Pyrethroid

The fastest growing family of insecticides in recent years has been the pyrethroid insecticides. Chemically, these are related to naturally occurring insecticides, pyrethrins, found in certain flowers. Examples include esfenvalerate, bifenthrin, and permethrin. The pyrethroid insecticides are highly effective against susceptible insects (e.g., caterpillars, leaf beetles) and are typically used at rates of active ingredient that are several times lower than organophosphate and carbamate insecticides. Most pyrethroids are relatively non-toxic to mammals, although some formulations have been associated with human irritation and allergic reactions. Most pyrethroids are highly toxic to fish.

FAMILIES OF FUNGICIDES

Organic sulfur

The most important family of fungicides in current use are the organic sulfur (carbamate) compounds derived from dithiocarbamic acid. Maneb, zineb, and thiram are examples of this fungicide family. The organic sulfur fungicides must be applied in a preventive manner and

will not control existing infections in a plant.

Benzene — Several benzene fungicides occur, such as chlorothalonil and PCNB. These fungicides also are used as protectants.

Benzimidazole — The benzimidazole fungicides have been the most important group of fungicides with systemic activity. Benomyl, thiabendazole, and thiophanate methyl are examples of this fungicide class. Because of their systemic activity, they can help to control some diseases after infection. Benzimidazole fungicides are also used to prevent post-harvest rots and as soil-drench treatments.

Sterol inhibitor — Sterol inhibitor fungicides are one of the newer fungicide families. Bayleton and Banol are examples of sterol inhibitor fungicides. The sterol inhibitors are systemic in the plant and have eradicant activity.

WOOD PRESERVATIVES

Creosote — Creosote and creosote solutions are an oily by-product of making coke from bituminous coal. They have been widely used as a preservative for such products as railroad ties, large timbers, fence posts, poles, and pilings. Creosote based preservatives are toxic to wood-destroying fungi, insects, and some marine borers. They are easy to apply and are insoluble in water. Creosote has low volatility and does not readily produce fumes. However, creosote treatment of wood results in a dark color with strong odor. Creosote tends to "bleed" and the wood surface remains oily and unpaintable. Creosote-treated wood can not be used in homes or other living areas.

Pentachlorophenol — Oil-borne preservatives include wood preservatives such as pentachlorophenol (penta). These chemicals are generally insoluble in water and must usually be dissolved in organic solvents in order to penetrate wood. The oil-borne preservatives are toxic to fungi (including mold) and insects as well as to plants, animals and humans. However, for some applications, these preservatives provide less physical protection than does creosote. Treated wood can have an unpaintable surface (depending on the carrier) and produces toxic fumes. Wood treated with oilborne preservatives should not be used in homes or other living areas.

Metallic salts — Water-borne preservatives include various metallic salts and other compounds. The principal compounds used are combinations of copper, chromium, arsenic, and

fluoride. Waterborne preservatives have gained increasingly wider usage for lumber, plywood, fence posts, poles, pilings and timbers. The treated wood surface is left clean, paintable, and free of objectionable odors. The waterborne preservatives also resist leaching and can be used in living areas or for playground equipment. The preservative copper-8-quinolinolate also has been approved for food contact uses such as for boxes, crates, and pallets used in the harvesting, storage, and transportation of food. However, water-borne preservatives do not protect the wood from excessive weathering. They also require that the wood be redried after treatment to prevent warping and checking.

ANTIBIOTICS

Anti-biotics

Antibiotics are substances produced by one organism that are toxic to another organism. Most antibiotics in current use have been products of bacteria-like soil organisms known as actinomycetes. Antibiotics are used in medecine as well as in pest management. Examples include streptomycin, tetracyclines, and avermectins. Control of the bacterial fruit tree disease fire blight with streptomycin is one of the greatest non-veterinary uses of antibiotics in agriculture. More recently avermectins have become available for control of spider mites and leafminers on greenhouse crops, and for control of livestock parasites.

FUMIGANTS

Fumigants

Pesticides which are primarily used as toxic gases are known as fumigants. Methyl bromide, aluminum phosphide, and paradichlorobenzene are examples. Most fumigants kill susceptible pests that breathe the gases into lungs (mammals) or spiracles (insects, mites). Some fumigants may also enter through skin and be corrosive to eyes. Many fumigants, particularly those used for control of stored grain insects and in rodent control, are extremely toxic and hazardous to apply. Less common uses of fumigants in Colorado are to control nematodes, soil-borne fungus diseases, and weeds in crop land. Forestry uses of fumigants have declined sharply since the banning of ethylene dibromide (EDB).

Some pesticides applied to soil or foliage may also have some fumigant activity. For example, some of the parathion applied to a crop will volatilize into a gas state and act in a fumigant manner. Several soil applied herbicides move through the soil in a gaseous state.

However, these types of pesticides are generally not considered to be true fumigants since they are not primarily used as a gas for pest control.

Because of the special hazards involved in the application of the more hazardous fumigants, special training is required. With use of these products requires special protective equipment and supervision. In addition, fumigant uses for prairie dog control require a pre-treatment survey be made to determine that the highly endangered black-footed ferret is not present at the site. Fumigant properties and applications are covered in a separate chapter.

PESTICIDE FORMULATIONS

Pesticides used in agriculture consist of a variety of formulations. These contain the active pesticide ingredient plus various "inert ingredients". The latter are used to improve the performance of the pesticide by affecting such characteristics such as handling, persistence on foliage, safety, ease of application, and ability to mix with water. Some of the more common formulations follow:

Emulsifiable concentrates

Emulsifiable concentrates (EC or E) are common liquid formulations of pesticides which have active ingredients that are insoluble in water. These formulations include the addition of an "emulsifier" which allows the pesticide to mix with water. This mixture is called an emulsion. Emulsifiable concentrates tend to penetrate skin more readily than other formulations so they require special care in handling. Also, inadvertent plant injury (phytotoxicity) is most commonly associated with this type of formulation because of the various additives. In addition, many "inert" ingredients found in emulsifiable concentrates are highly corrosive to eyes. Emulsifiable concentrates often may be seriously affected if exposed to very cool or freezing temperatures which can "break" the emulsion.

Wettable powders

Wettable powders (WP or W) are pesticides that are formulated on a dry particle and contain ingredients that allow the particles to mix with water. The resulting mixture is referred to as a suspension. Continuous agitation is required when using wettable powders to prevent them from settling in a spray tank. Wettable powders may also cause increased wear on sprayer equipment. Because they occur as dust-like particles, they can be easily inhaled during mixing if protective equipment is not used. However, wettable powder formulations often are quite safe to use on plants. They are used extensively in greenhouse and fruit production

where plant injury is great concern.

Flowables dry/ liquid

Dry flowables/water dispersible granules are the fastest growing new formulation, largely replacing many wettable powder formulations. Ease of handling and reduced hazards from blowing dusts during mixing are two reasons for the adaptation of dry flowable formulations. They form a suspension when mixed with water and require less agitation than wettable powders. A further advantage of flowables over wettable powder formulations is that they cause less wear on equipment.

Flowables (F) are formulations of pesticides which can only be produced in solid or semi-solid form. They are often ground into a fine powder and suspended into a liquid. Flowables are produced for uses where they are more easily handled and mixed than wettable powders.

Soluble powders

Soluble powders (SP or S) are dry formulations of pesticides that will go into true solution when mixed with water. Because of this characteristic, soluble powders do not require agitation after mixing. Relatively few pesticides are water soluble. These pesticides may also be formulated as liquids (L).

Dusts

Dusts are formulations of pesticides on a dry particle that are designed to be applied dry. Formerly widely used, few dust formulations are currently made. Problems include difficulties in applying with currently used equipment, excessive drift, increased hazards to honeybees, and applicator inhalation problems. Currently, dust formulations are most often found in garden pesticide formulations and for applications made to livestock, pets, and poultry. Dusts used as "tracking powders" are also used for rodent control.

Granules

Granules (G) are dry formulations mixed onto fairly large particles of clay, ground corn cob or walnut hulls, or manufactured granules. Until wetted, most of the pesticide remains attached to the granule, making these a less hazardous formulation to handle than liquids. Due to their heavy weight, granules have the advantage of being able to sift down into plant parts such as corn whorls or grass and are not very susceptible to drift.

Microencapsulation

Microencapsulated pesticides are impregnated into tiny, slow release plastic beads and mixed into a liquid. Pesticides formulated in this manner are often much safer to humans than other liquids and may have somewhat longer residual life. However they are often somewhat more expensive and can increase hazards to honeybees.

Numerous other formulations can be found for specialized purposes, primarily to increase ease of application and effectiveness. Ultra-low volume (ULV), aerosol, smoke bomb, paints and bait formulations are among these other specialty products.

ADJUVANTS

Adjuvants are substances added to aid in the operation of the main pesticide ingredient. Many times, the performance of a pesticide is greatly improved by the addition of an adjuvant which corrects certain application problems on the crop. When added by the user, these products are exempt from the food crop tolerance requirements that affect pesticides used on food crops. Some common types of adjuvants are:

-Wetting agents or surfactants are used to improve spread of a spray mixture on foliage. Surfactants are most commonly used to apply pesticides on plants with very waxy or hairy leaves;

-Stickers improve the weatherability of a spray deposit, particularly from washing by rainfall or irrigation;

-Synergists greatly increase the activity of insecticides by blocking the ability of the insect from breaking down the insecticide;

-Penetrants are used to increase uptake of herbicides into a plant;

-Buffers are used in spray tanks to decrease break down of the pesticides that occurs from exposure to alkaline water conditions.

INERT INGREDIENTS

Essentially all pesticides offered for sale to growers do not contain 100% of the pesticide active ingredient. Instead pesticides are formulated in some manner by the manufacturer. During formulation various diluents or adjuvants are added to the active pesticide ingredients. The subsequent formulation of the pesticide may greatly affect its performance and use and each formulated pesticide is individually registered by the EPA. The percentage of these adjuvants is indicated on the pesticide label as inert ingredients.

Despite what the term might indicate, inert ingredients may have some biological activity and certain inert ingredients are associated with increased pesticide hazards. As with the active ingredients, many inert ingredients are being reviewed by the Environmental Protection Agency.

MIXTURES OF PESTICIDES

It is often desired to mix two or more pesticides during application or to mix pesticides with fertilizers. When these mixtures can be made without reducing safety or effectiveness the mixture is said to be compatible. However, often such mixtures can not be made since the the chemicals are incompatible. Incompatible mixtures can increase the toxicity or hazard of the mixture to the applicator or the environment. Incompatible mixtures may also greatly reduce the effectiveness of the spray mixture or may cause crop injury.

Physical incompatibility

Incompatibility can involve undesirable physical changes in the mixture. For example a mixture may cause material to precipitate as a solid and deposit on the bottom of the spray tank. Physical incompatibility may also cause the components to form separate layers following agitation. Large aggregates may form, or curdling of the mixture may occur. These types of physical incompatibilities may result in an unsprayable mixture or cause fluctuations in the amount of pesticide being applied.

Chemical incompatibility

Chemical changes may also occur when mixtures of pesticides or pesticide-fertilizer combinations are made. This is particularly common where highly acidic or alkaline materials are used. Reactions in the tank may form compounds that increase environmental hazards, reduce the amounts of active ingredients, or cause plant injury.

Increasingly, tank mixes of two or more compounds are specified on pesticide labels. Compatability problems should be minimal with these previously tested and registered combinations. Where such combinations are not specifically labelled, private pesticide applicators may make such tank mixtures unless the label instructions prohibit. However, where specific tank mixes have not been extensively tested, use caution to avoid problems. Often testing procedures for determining incompatibility are outlined on the product label.

HAZARDS ASSOCIATED WITH PESTICIDES

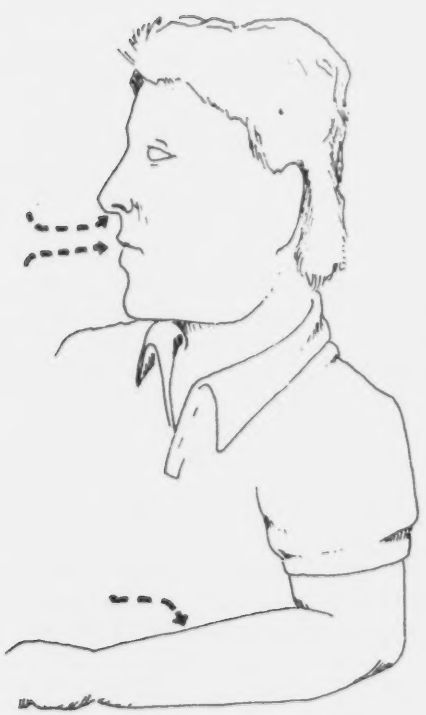
All pesticides are economic poisons, designed to harm pest species. As such they have associated hazards that must be recognized and respected by the pesticide applicator. Among these hazards are poisoning of the applicator or farmworkers, destruction of beneficial insects that aid in pollination or pest control, injury to plants, damage to wildlife, and contamination of surface and ground water supplies.

PESTICIDE POISONING

To varying degrees, pesticides are toxic to humans. Toxicity of the pesticide is the innate capacity of the the chemical to be poisonous. Although occurrence of poisoning is related to the amounts received during exposure, highly toxic insecticides generally have greater capacity to cause poisoning. Exposure to pesticides occurs through the skin and eyes, by ingestion, and from inhalation.

Routes of exposure

Pesticides can enter the body by dermal exposure when absorbed through the skin. This is particularly important when liquid pesticides, such as emulsifiable concentrates, are used. High levels of skin exposure to pesticides can occur during mixing of concentrated pesticides that spill or splash. During application, sprays may drift onto skin or onto clothing.



The degree of skin absorption depends upon the type and formulation of the pesticide as well as the part of the body the pesticide contacts. Areas around the genitals and thinner areas of skin such as the forehead absorb pesticides most rapidly. Any break in the skin also enhances pesticide entry. Skin areas of burns, dermatitis, and eczema also allow increased absorption.

Splashing into the eyes can be extremely damaging when highly corrosive pesticides, such as lime sulfur, are used. Certain formulations of pesticides containing corrosive solvents, such as xylene, may also be very damaging to eyes.

Ingestion or oral exposure through the mouth may occur through ingesting splashed or drifted liquids or dusts during mixing and application. Smoking or eating with pesticide contaminated hands is another common means of ingesting pesticides.

Cleaning nozzles by blowing into them also allows for exposure to pesticides. Oral exposure is also a common means of accidental poisoning by children that consume pesticides in poorly marked containers kept in non-secure storages.

Pesticides in the form of dusts, spray mists, and fumigant gases allow inhalation exposure into the respiratory tract. The production of fine particles associated with high pressure spraying and aerosols are particularly easy to absorb through the lungs. Inhalation exposure can be particularly serious because the thin lining of air sacs in the lungs are easily damaged and can allow rapid movement into the blood stream.

Measuring toxicity/ LD50

The inherent toxicity of a pesticide is determined by various forms of laboratory testing on animals such as rats, mice, and rabbits. One commonly used measure of toxicity via ingestion or dermal exposure is a figure known as the LD_{50}. This figure is the dose that is lethal to 50% of a group of test animals. It is based on a single exposure to the chemical. The LD_{50} value is standardized based on the weight of the test animals being expressed as the number of parts of pesticide per million parts of body weight (milligrams of pesticide per kilogram of body weight). Low LD_{50} numbers indicate more toxic pesticides than do higher numbers, since less chemical is required to produce poisoning effects.

LC50

When assessing the toxicity of fumigant pesticides a slightly modified system is used. The LC_{50} value involves the testing of animals exposed to various concentrations of the pesticide in air. A similar system is used to test effects of chemicals against aquatic organisms in water.

It must be recognized that these means of testing chemical toxicities is only approximate since it involves species other than man as indicators of toxicity. It also is a median value, and does not indicate the effects on more resistant or susceptible individuals. Despite these limitations, the LD_{50} system can be used to assess the relative risks when comparing different chemicals.

Hazard

The hazard of a pesticide is different from its toxicity. Hazard is the degree of danger involved in using a pesticide under certain conditions of use. Hazard varies depending on the exposure to the chemical and can be expressed as the equation of exposure times toxicity. The toxicity of pesticides is a "built in" characterisitic. However, we can often reduce hazard by

taking steps that minimize exposure to the pesticide. Various formulations, methods of application, protective clothing and equipment all can greatly affect the hazards of a pesticide.

Acute toxicity

Acute toxicity refers to poisoning following single exposures, such as may occur during accidents in mixing and applying pesticides. Various signs and symptoms are associated with these poisonings. "Symptoms" of pesticide poisoning refer to feelings noticed only by the person who has been poisoned, such as nausea or a headache. "Signs" of pesticide poisoning, such as vomiting, are those results of poisoning which can be noticed easily by others. Persons working with pesticides or in pesticide treated areas should learn the signs and symptoms of pesticide poisoning to avoid serious injury and to allow prompt treatment.

Symptoms of poisoning

Pesticides in the same related chemical family tend to cause similar kinds of poisoning sickness. Often these poisonings produce a characteristic pattern that also help in diagnosis.

Organophosphate and carbamate insecticides act on the nervous system, depressing levels of the chemical cholinesterase which functions in nerve transmission. Signs and symptoms of poisoning by these insecticides follows the pattern of:

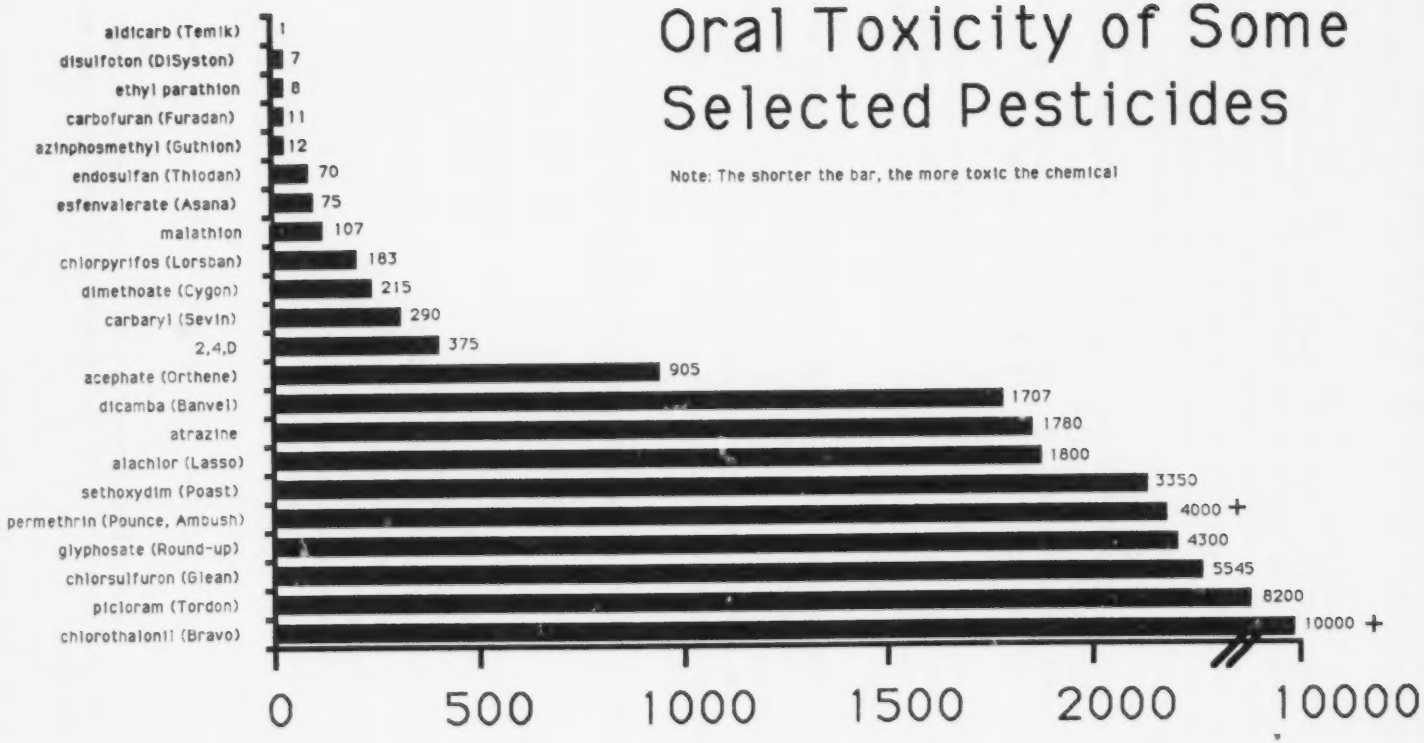
Symptoms Associated with Organophosphate and Carbamate Poisoning

Mild poisoning	Moderate poisoning	Severe poisoning
Fatique	Inability to walk	Unconsciousness
Headache	Weakness	Severe constriction of the eye pupil
Dizziness	Chest discomfort	Muscle twitching
Excessive sweating	Muscle twitching	Secretions from mouth and nose
Salivation	Constriction of the eye pupil	Breathing difficulty
Nausea, vomiting	Increase in earlier symptoms, signs	Death, if untreated
Stomach cramps		
Diarrhea		

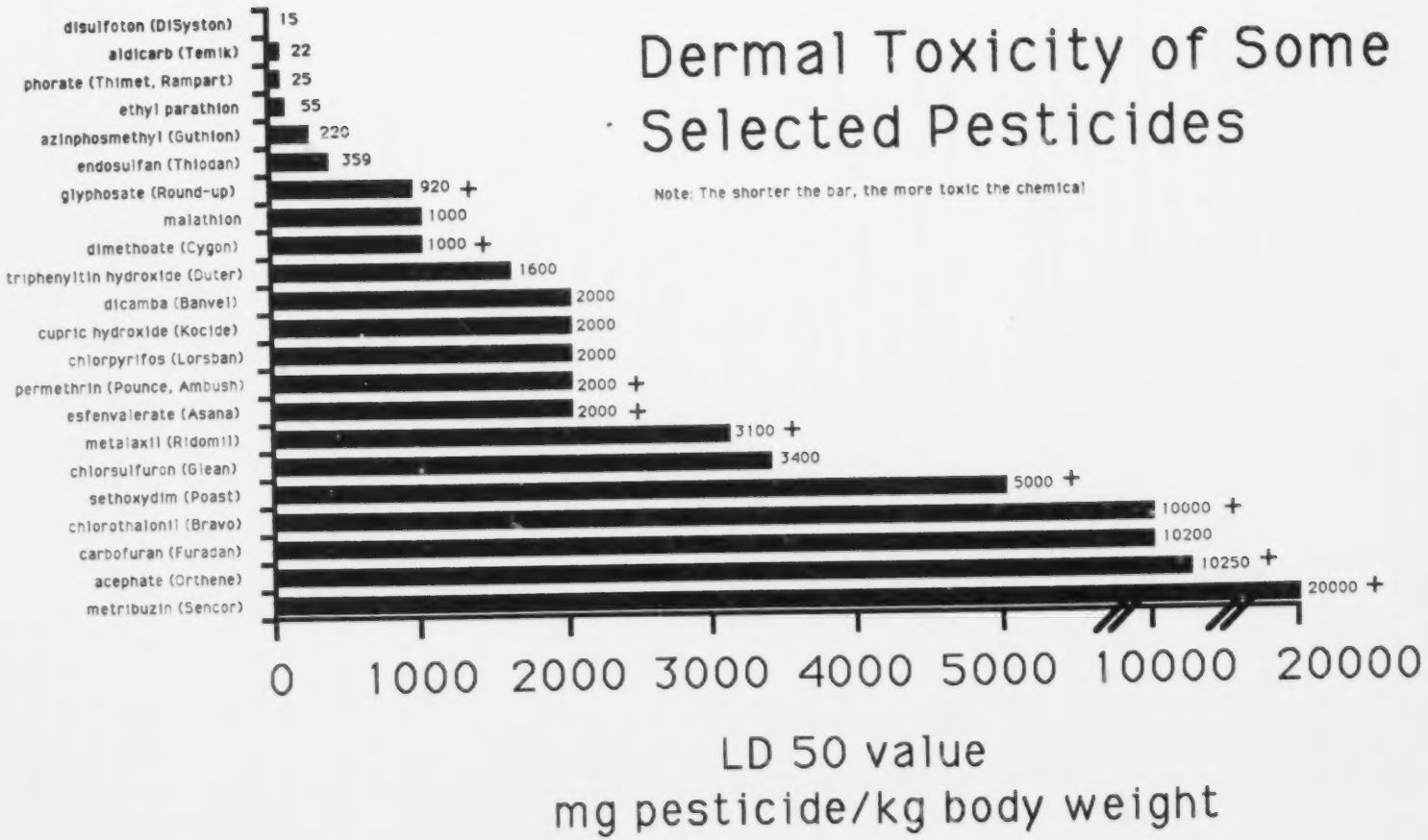
NOTE: There is extensive overlap of symptoms between various described stages of poisoning. **If poisoning symptoms are suspected seek medical attention.**

Oral Toxicity of Some Selected Pesticides

Note: The shorter the bar, the more toxic the chemical



LD 50 value
mg pesticide/kg body weight


Dermal Toxicity of Some Selected Pesticides
Note: The shorter the bar, the more toxic the chemical
disulfoton (DiSyston) 15
aldicarb (Temik) 22
phorate (Thimet, Rampart) 25
ethyl parathion 55
azinphosmethyl (Guthion) 220
endosulfan (Thiodan) 359
glyphosate (Round-up) 920 +
malathion 1000
dimethoate (Cygon) 1000 +
triphenyltin hydroxide (Duter) 1600
dicamba (Banvel) 2000
cupric hydroxide (Kocide) 2000
chlorpyrifos (Lorsban) 2000
permethrin (Pounce, Ambush) 2000 +
esfenvalerate (Asana) 2000 +
metalaxil (Ridomil) 3100 +
chlorsulfuron (Glean) 3400
sethoxydim (Poast) 5000 +
chlorothalonil (Bravo) 10000 +
carbofuran (Furadan) 10200
acephate (Orthene) 10250 +
metribuzin (Sencor) 20000 +
0 1000 2000 3000 4000 5000 10000 20000
LD 50 value
mg pesticide/kg body weight

Chlorinated hydrocarbon and pyrethroid insecticides have been less commonly associated with acute poisoning than the above insecticides. Early signs and symptoms of poisoning include: headache, nausea, vomiting, general discomfort, and dizziness.

Poisoning may progress to include increased excitability or irritability, convulsions and occasionally, coma and death.

Bipyridylium herbicides, such as paraquat and diquat, are among the more hazardous pesticides since poisoning injuries can be irreversible. Exposed cells can be killed so that permanent damage occurs, inducing problems such as lung fibrosis. Skin contact can produce severe skin irritations.

Phenoxy herbicides, such as 2,4-D and MCPA, most often cause skin irritation or a local burning sensation when inhaled. Dizziness or chest pain may result from prolonged inhalation. When large quantitities of the pesticide are absorbed, muscle twitching, muscle tenderness, and muscle stiffness may occur.

Wood preservatives have been associated with a variety of acute and chronic hazards. This has led to their recent classification as Restricted Use pesticides. Creosote exposure can cause skin irritation and prolonged exposure may lead to dermatitis. Vapors and fumes of creosote are irritating to eyes and the repiratory tract. Pentachlorophenol is also irritating to eyes, skin, and the respiratory tract with prolonged exposure sometimes leading to an acne-like skin condition. Ingestion of penta solutions, excessive skin contact, or inhalation of concentrated vapors may lead to fever, headache, weakness, dizziness, nausea, and profuse sweating. Extreme cases can induce loss of coordination and convulsions. Pentachlorophenol can be fatal. Arsenical wood preservatives can cause nausea, headache, diarrhea, and abdominal pain (if the material is swallowed). Extreme symptoms can progress to dizziness, muscle spasms, delirium and convulsion. Prolonged exposure to arsenical wood preservatives can result in persistent headache, abdominal distress, salivation, low grade fever, and upper respiratory irritation.

Fumigant pesticides can often be extremely hazardous to apply. Methyl bromide and phosphine (released by the exposure of aluminum phosphide to water) damage the cells lining the air sacs in the lung. Fluids accumulate in the lungs following this injury, a major cause of death from fumigant exposure. Fumigants such as methyl bromide

may also irritate heart muscles leading to heart attack. Liver and kidney damage are also associated with exposure to many fumigant pesticides.

Signs and symptoms of fumigant poisoning often resemble those associated with drunkeness (alcohol poisoning). These include poor coordination, slurring of speech, confusion, and sleepiness.

Among the botanical insecticides, nicotine has a high degree of associated hazards when used as a spray or a fumigant to control greenhouse insect pests. Nicotine is very rapidly absorbed through the skin as well as through inhalation during these applications. Skin burning and irritation can occur from mild exposure. Stimulation and excitability, followed by extreme depression, are common advanced poisoning symptoms. Nicotine poisoning can be serious, and even fatal, causing death by paralysis of muscles used in breathing.

Chronic toxicity

Chronic toxicity describes effects of prolonged or repeated low level exposures to a toxic substance. Chronic effects are not generally observable immediately following exposure and may take very long periods to produce signs and symptoms. Some types of chronic poisoning that can occur include:

Carcinogenicity-ability to produce cancer or to indirectly promote carcinogenic chemicals;

Mutagenicity-ability to cause genetic changes;

Teratogenicity-ability to cause birth defects;

Oncogenicity-ability to induce tumor growth (not necessarily cancers);

Liver damage;

Reproductive disorders (reduced sperm count, sterility, miscarriage);

Nerve damage (including accumulative effects on cholinesterase depression associated with organophosphate insecticides);

Allergenic sensitization (development of allergies to pesticides or chemicals used in formulation of pesticides).

Problems with chronic toxicity, as with acute toxicity, are dose-related. That is, low-level exposure to

chemicals determined to have potential chronic effects may not produce injury. On the other hand, repeated exposures through carelessness and failure to follow label instructions, can greatly increase chronic risks.

Decisions to retain registrations of pesticides with chronic risks

Decisions by the Environmental Protection Agency (EPA) to continue registrations of pesticides with known or suspected chronic risks are often extremely complicated and involve several factors including:

-Weight of the evidence that the pesticide is capable of causing long-term injuries such as cancer, birth defects, or organ injuries;

-Amount of exposure during use of the pesticide, i.e., amount of hazard associated with its use;

-Number of people exposed to the pesticide at levels which may cause chronic effects.

Decisions to restrict pesticide uses consider many factors. The probability of pesticide exposure when used according to label directions is an important consideration. Methods of reducing this exposure by changing methods of using the pesticide (including protective clothing requirements, reentry intervals, etc.) are evaluated. Effective techniques that reduce pesticide exposure and are compatible with crop production practices may be adopted as labelled directions for use. Pesticides that are known or suspected of having associated chronic hazards will also include warning statements on the label. These statements are intended to provide informed consent agreements that applicators using these pesticides understand the associated hazards and follow all label precautions to prevent injury. **As with all pesticide uses, repeated evidence of applicator failures to use the pesticide in the lawful manner can lead to the pesticide being banned or more strictly regulated.**

RESISTANCE OF PESTS TO PESTICIDES

One of the most serious problems facing continued use of pesticides is the development of pesticide resistance in pest populations.

Pesticide resistance

Pesticide resistance develops from the selection of preadapted, genetically resistant individuals following repeated pesticide exposure. Following pesticide

applications, susceptible pests are killed, concentrating the number of individuals resistant to the pesticide. This is often termed selective pressure, since it involves selecting individuals that are already resistant or tolerant to the pesticide. Pesticide resistance does not involve developing tolerance to the pesticide following repeated small exposure. In other words, resistance does not develop because the insects get used to the pesticide exposure. Once established in a population, pesticide resistance remains permanent.

Resistance has led to the loss of many pesticides that formerly were effective for pest control in Colorado. Problems have been most severe in industries where pesticide use is most intensive, such as greenhouse, tree fruits, livestock, and vegetables. Resistance problems in Colorado have occurred with such insect and mite pests as pear psylla, two-spotted spider mite, green peach aphid, onion thrips, horn fly, and house fly. Resistance to fungicides has developed with certain Fusarium diseases. Weeds, such as lambsquarters and kochia, have also become resistant to herbicides.

Enhanced degradation

Another problem, known as enhanced degradation, has caused the loss in effectiveness of various soil-applied herbicides and insecticides following repeated use. This phenomena results in control failures that may superficially be considered evidence of resistance development. Instead, it involves the increase in soil microorganisms that break down the pesticide so that it is rapidly inactivated. Enhanced degradation has only recently been recognized as a problem in agriculture but, has already resulted in the loss of several pesticides in some locations. As with pesticide resistance, once problems have developed, the results are permanent.

Development of new pesticides is a long and costly procedure. It is in the best interests of a producer to minimize development of pesticide resistance and enhanced degradation by proper pesticide management. This is best achieved by using pesticides only when needed, to reduce the selective pressure that produces resistant pests. Also, it is often desirable to switch between classes of pesticides to further delay problems with reduced performance.

DAMAGE TO BIOLOGICAL CONTROL ORGANISMS

Use of pesticides can often severely affect the performance of biological control organisms. Most often damage has been associated with use of insecticides affecting predators and parasites of insect and mite pests. Fungicide use has also been

shown to adversely affect certain predators of spider mites and to inhibit naturally occuring fungus diseases of insect pests.

Secondary pest problems

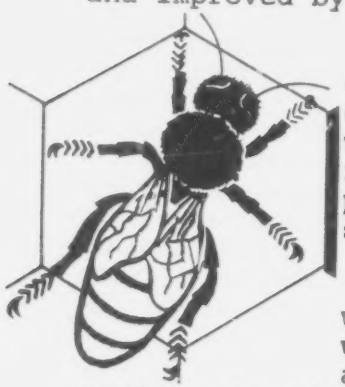
Several consequences can occur when the existing biological control organisms are disrupted and destroyed. Secondary pest problems develop when normally non-economic pest species become serious pests because natural enemies are destroyed by pesticides. Many of the problems with spider mites in fruit and field corn are secondary pest problems; pea aphid problems in alfalfa commonly are induced by alfalfa weevil treatment.

Pest resurgences

Pest resurgences or rebounds occur when the pest species is only temporarily reduced by pesticide applications. If the natural enemies of the pest are also affected, the pest may increase rapidly after pesticide residues decline to ineffective levels.

DAMAGE TO POLLINATING INSECTS

Pollinating insects, such as honeybees and leafcutter bees, are extremely important in the production of a wide variety of fruit and seed crops. Crop yields and quality are often dependent upon and improved by the activities of pollinators.



In addition, industries surrounding the culture of honeybees have long been an important part of Colorado agriculture. Millions of dollars of honey, wax, and other honeybee products originate from the region. Income derived from the sale of these products is often a primary, or important secondary, source of farm income.

Often, pesticide use practices are in conflict with pollinating insects. This occurs most commonly when pesticides that are hazardous to honeybees are applied to areas visited by worker bees or when toxic pesticides drift onto bees clustered on the outside of hives. Protection of excessive honeybee losses from bee kills is an important consideration of pesticide applicators.

PHYTOTOXICITY

Crop injury can also occur inadvertently from certain pesticide applications, a problem known as phytotoxicity. This is most important when using "selective" herbicides that are selective only by having a higher margin of safety to the crop than to the weed. Phytotoxicity is also a common problem with many insecticides and fungicides used in production of sensitive greenhouse crops. Many corn rootworm insecticides are phytotoxic if placed in contact with the seed. Occasionally, phytotoxic problems can develop when two pesticides are applied to a crop and

damage occurs that is not present when only one pesticide is used.

For the most part, phytotoxicity hazards are recognized during pesticide development. Warning statements then are placed on the pesticide label giving directions on how to avoid injuries.

HAZARDS TO WILDLIFE AND ENDANGERED SPECIES

Many pesticides have potential to seriously injure wildlife. It has been an important reason for the elimination or sharp reduction in populations of birds, certain mammals, and other species in many areas of intensive agriculture in Colorado. In some cases, pesticide use has even caused wildlife species to become seriously endangered with extinction.

Damage to wildlife

Pesticides can affect wildlife populations in a number of ways, including:

-pesticides directly applied to wildlife habitats can directly kill plants and animals.

-pesticides can run-off a site and contaminate water that is ingested or inhabited by wildlife.

-pesticides can eliminate food used by wildlife.

-pesticides can accumulate in predators that feed upon plants or animals that have been exposed to pesticides.

-pesticides can damage or elminate habitat required for the survival of wildlife.

Endangered species

Among the species that have been most directly affected by pesticides in Colorado are the black-footed ferret and the peregrine falcon. Indiscriminate poisoning of prairie dogs eliminated the black-footed ferret from much of its original range to the point where it is now the rarest mammal in North America. Peregrine falcons, and many other birds of prey, were severely affected by the accumulation of DDT and persistent industrial chemicals (PCBs) which interfered with their ability to reproduce.

Populations of other endangered species of wildlife have been devastated by habitat losses, water pollution, and overhunting.

The following species of animals, found in Colorado, are nationally recognized as being endangered species. These animals

are considered to be in greatest danger of extinction and require most stringent protections:

Mammals	Birds	Fish
Black-footed ferret	Peregrine falcon	Colorado squawfish
Gray wolf	Bald eagle	Humpbacked chub
	Whooping crane	Bonytail

Plants

Spineless hedgehog cactus
Knowlton cactus
Siler pincushion cactus
Mancos milk-vetch
North Park phacelia
Clay-loving wild buckwheat

In addition there are several species of wildlife that are regionally endangered or threatened including:

Mammals	Birds	Fish
River otter	Greater sandhill crane	Razorback sucker
Grizzly bear	Greater prairie chicken	Green cutthroat trout
Lynx	Lesser prairie chicken	Arkansas darter
Wolverine	Plains sharptailed grouse	

Amphibians	Plants
Wood frog	Uinta Basin hookless cactus
	Mesa Vere cactus

The Endangered Species Act requires that protective measures be taken to conserve threatened and endangered species. Protection of all these species will require limitations on certain pesticide uses. Final regulations have not yet (1988) been drafted but are expected to require that pesticide users become aware of endangered species in their area and to take protective measures against their harm. Certain restrictions of pesticide uses are also likely to protect endangered species of wildlife in Colorado. These regulations will be particularly restrictive in areas of Colorado where endangered species of wildlife inhabit. These counties currently include (but may not be limited to):

Boulder	Jackson	Mesa
Delta	La Plata	Montrose
Fremont	Larimer	Park
Gilpin	Mesa	Rio Blanco
	Moffat	

However, many threatened and endangered species migrate across large areas of Colorado, such as the whooping crane and bald eagle.

Others, most importantly the black-footed ferret, may still exist in isolated prairie dog towns. It is always important that a pesticide user makes all pesticide applications in a manner that protects wildlife.

PESTICIDE DRIFT

Pesticide drift is the movement of a pesticide to areas other than the intended area of application. Some drift is inevitable during applications and short-range drift can aid in crop coverage. However, small particles of spray droplets or dusts can be carried by air movement and drift for great distances away from the application site. Pesticides may also drift when pesticides evaporate from the crop and travel as fumes.

Pesticide drift can harm sensitive crops, garden, landscape, and shelterbelt plantings. Pesticide drift can also cause illegal residues to occur on crops. Drifting pesticides can injure livestock, honeybees, and wildlife. Humans may also be exposed to pesticides by drift. Pesticide performance can also be reduced if excessive drift occurs.

Several factors affect the potential for pesticide drift. Among the more important factors are the inherent drift hazard of a pesticide, pesticide formulation, droplet sizes produced during application, height of pesticide release, temperature and air movements during application. Management of drift is an important consideration during pesticide application. Failure to take proper precautions can cause injury or losses on your own property as well as cause "chemical trespass" to neighboring properties.

POLLUTION OF WATER RESOURCES

Contamination of surface waters has long been a recognized concern surrounding pesticide uses. Such contamination can occur directly by drift or accidental application of pesticides into waters at the time of application. Extreme care must always be taken when making pesticide applications near waterway.

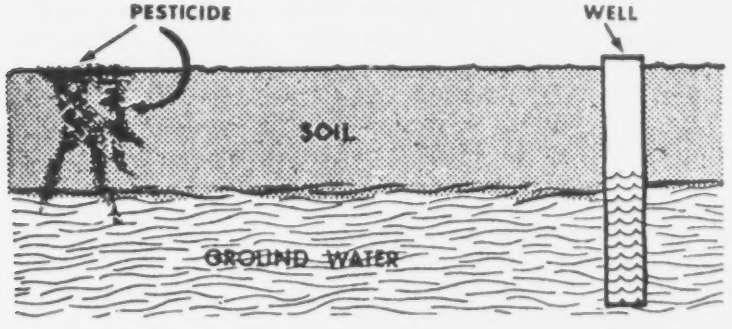
Erosion Pollution of water by pesticides may also occur from run-off following irrigation or rainfall. Wind blown soil contaminated by pesticides may also enter surface waters. These problems are most severe if substantial erosion occurs shortly after a pesticide application. Site conditions that favor erosion (slope, exposure, etc.) greatly increase the potential of unwanted pesticide movement from erosion.

Groundwater contamination More recently, attention has shifted to problems with groundwater contamination by pesticides and various industrial chemicals. This groundwater is the water source for wells and springs. About one-half of the

population of the United States relies upon groundwater for drinking; in rural areas 90 percent of drinking water is from groundwater sources. Groundwater was long thought to be relatively protected from pollution sources and the discoveries of pollution have raised serious concerns. In addition there has been increased awareness that groundwater and surface water resources are often interconnected.

Groundwater is maintained in an aquifer, a water saturated zone of soil, sand, gravel, or fractured bedrock. The upper layer of the aquifer is known as the water table. These underground water sources are maintained by percolating water, or recharge, that passes through soil into the water table. When this downward percolating water contains dissolved chemicals the process is known as leaching. Leaching of soil salts has long been an important aspect of irrigation practice in areas of high salt content.

Groundwater becomes contaminated when recharge water carries pollutants with it to the water table. Once in the aquifer, water then travels in a more horizontal direction. These chemicals move with the groundwater, forming a region of contaminated water known as a plume.



Once contaminated, groundwater may be prohibitively expensive or impossible to clean-up. Since pesticides degrade very slowly in groundwater, results of contamination may last for many years. Clearly, the best solution is to keep pesticides and other chemicals out of groundwater through careful use in application, storage, and disposal.

A number of factors contribute to a potential problem with groundwater contamination. These include site conditions, characteristics of the pesticide, the method of application, and environmental conditions following application.

Site conditions

Site conditions associated with groundwater contamination potential include:

Soil texture, determined by the relative proportion of sand, silt, and clay. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer than soils of low clay and organic matter content. Clay and organic matter also adsorb, or hold onto, many dissolved chemicals. Sandier soils increase risks of contaminated water moving into groundwater. Many Colorado agricultural areas, such as the northeast, have very sandy soils; Soil permeability, a measure of how rapidly water is able to percolate through a soil. Highly permeable soils allow for greater downward movement of water-borne contaminants. Many Colorado areas, such as the San Luis Valley, have very permeable soils;

Soil organic matter. Organic matter content influences how much water a soil can hold and how well the soil can adsorb chemicals, including pesticides. Low organic matter soils are common in Colorado;

Soil pH. The relative acidity or alkalinity of soil can be important in the degradation of the pesticides. Most pesticides degrade more rapidly under alkaline conditions.

Depth of water table. Water table depth influences the rapidity with which dissolved chemcials can enter the underlying aquifer. Also pesticides degrade slowly in groundwater since few microorganisms occur to break down the pesticide. In areas of high water tables, such as parts of the San Luis Valley, groundwater contamination risks can be greatly increased. Areas along streams and rivers are also at high risk of contaminating groundwater supplies through careless pesticide use.

Pesticide characteristics

Characteristics of the pesticide that can influence hazards to groundwater include:

Water solubility. Solubility of a pesticide is important in how freely the pesticide dissolves in and moves with water. Highly water soluble pesticides, such as many carbamate insecticides and triazine herbicides are among the more readily leached pesticides.

Environmental persistence. Persistence of the

pesticide, or its ability to resist degradation, affects groundwater contamination risks. Pesticides which resist degradation increase potential to enter groundwater.

Electrical charge. Charge, or speciation, of the chemical is important in how readily it will adsorb or bind to soil particles. Since clay and organic matter tend to be negatively charged, chemicals with a positive charge will most readily cling to the soil and resist leaching. Negatively charged pesticides, or soils with few negatively charged clay and organic matter particles, increase leaching potential.

Application — Application and use of the pesticide can influence groundwater contamination risks, such as:

High use rates which can increase the amount of pesticide available to leach and contaminate water sources;

Excessive irrigation which can increase water flow and leaching;

Chemigation techniques which pose special potential hazards to groundwater. If power failure occurs during application, back siphoning of chemicals is possible. This draws large amounts of non-degraded pesticides directly into the well causing serious groundwater contamination. Appropriate protective devices, such as check valves, are now required by law and label instructions to prevent accidental back siphoning pollution of wells.

"Leachers" — Several pesticides have been found contaminating groundwater supplies throughout the United States. These compounds, or ones with similar chemical characteristics, are sometimes classified as "leachers" by the Environmental Protection Agency. Use of these products should involve extra precautions to prevent groundwater contamination. A list of those pesticides detected in groundwater (up to 1988) includes:

alachlor (Lasso)
atrazine (AAtrex)
carbofuran (Furadan)
DBCP
dicamba (Banvel)
metolachlor (Dual)
picloram (Tordon)
Simazine
aldicarb (Temik)
bromacil
cyanazine (Bladex)
dacthal/DCPA
fonofos (Dyfonate)
metribuzin (Sencor)
oxamyl (Vydate)

MANAGEMENT OF COMMON AGRICULTURAL PESTS IN COLORADO

Essentially all crops grown in Colorado are subject to competition and attack by certain pest species. Information on the management of these pests is available from various sources, such as the Colorado State University Cooperative Extension, ag-chemical suppliers, and agricultural consultants. Examples of management techniques for some common agricultural pests follow.

CANADA THISTLE

Canada thistle is an aggressive and serious weed pest of pasture and cultivated crops. Infestations typically originate in disturbed ground, such as overgrazed pastures, tilled fields and waste areas. Once established, the weed spreads by means of underground rhizomes, creating circular patches. Root pieces, cut by cultivation, may also regrow and spread an infestation. In addition, large numbers of seeds are produced during late spring and early summer which blow and spread the weed to new areas. Canada thistle is recognized as a noxious weed under Colorado law.

In cropland, best control of the weed is achieved by persistent cultivation. Use of a duck-foot cultivator which cuts the plant no deeper than 4 inches below the surface is suggested for this cultivation. Plants are particularly susceptible to cultivation shortly before flowering, when root food reserves are lowest.

Planting cropland to highly competitive crops, such as small grains and alfalfa can help decrease growth of the weed. In grain crops, rangeland, and pasture, a few selective herbicides can be used to help control Canada thistle. Use of herbicides is particularly effective when applied in fall, shortly before a killing frost. During this period, the herbicide is most likely to be carried to and kill the root system.

LEAFY SPURGE

Leafy spurge is considered to be the most important weed threatening pasture lands in Colorado. The weed is not palatable to cattle since it produces a milky sap that is very irritating to cattle. Leafy spurge is highly aggressive and can rapidly outcompete desirable forages. A relative newcomer to Colorado, leafy spurge has eliminated large areas of rangeland from more northern states which spend millions of dollars in its management. Leafy spurge is recognized as a noxious weed.

The seed is primarily spread by birds, humans and water. Spread along ditchbanks and streams has been a

common means of movement in Colorado. Once established in an area, leafy spurge spreads by means of an extensive creeping root system which produces numerous new plants. The root system contains large numbers of nutrient reserves which help the plant survive many control attempts.

Whenever possible, intensive cultivation can control leafy spurge. In rough terrain where this is not practical, use of specialized equipment which can lift and damage the roots can help help provide control by exposing the the roots to disease organisms. This is most effective if done at flowering. Herbicides can provide control when applied correctly. Proper timing of applications is important and varies with the different types of herbicides used for leafy spurge control.

JOINTED GOATGRASS

Jointed goatgrass is a serious weed of winter wheat. It has a winter annual life cycle, similar to that of the crop, germinating primarily in fall. The plants resume growth in spring, usually flowering and setting seed shortly before wheat. Occasionally, jointed goatgrass will hybridize with wheat. Jointed goatgrass has been declared a noxious weed in Colorado since 1978.

Seeds are in the form of small cylinders which superficially may resemble small (1/2 inch) pieces of wheat stem. Because of this similarity, many farmers have unkowingly planted the weed, contributing to its spread. Once established in a winter wheat planting it is extremely difficult to control since it is so similar to the crop that selective herbicides are not available. Seeds may also remain viable for several years, particularly if deeply buried during plowing.

Farmers should prevent the spread of jointed goatgrass into their own fields by learning to recognize the weed seeds and to inspect all seed lots for presence of the weed. Since infestations can also originate from infested roadsides, these areas should also be surveyed and treated for the weed. Once established, rotation to a spring crop should be considered where more effective herbicidal control is possible.

MUSK THISTLE

Musk thistle is a biennial weed problem of pasture and rangeland. Musk thistle often occurs as a large plant and problems with the weed result from the long spines it produces. To avoid the spines, livestock do not feed on forage around the weed.

Although musk thistle can become a problem even on good

pastureland, the weed has more difficulty becoming established in vigorously growing grass. Herbicides are often used to control the weed. Musk thistle is most sensitive to herbicide treatment while the plant is in the rosette stage, before it produces a seed spike.

A species of weevil which feeds on the developing seeds of musk thistle has been introduced into Colorado.

LARKSPURS

The larkspurs are important weeds of range because they can be poisonous to cattle, occasionally causing death. Horses are also susceptible to the effects of the weed but usually do not consume enough foliage to cause poisoning. Sheep are generally not poisoned by larkspur feeding.

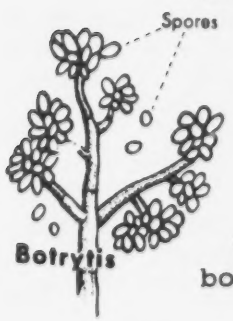
Two groups of larkspurs are generally recognized. The tall larkspurs generally inhabit moist meadows or woodlands at high elevations. The low larkspurs can be found in the foothills and at lower elevations, in drier environments. Larkspurs are perennial, reproducing by both seeds and by tubers or rhizomes.

The plants produce a rosette of green growth early in the season, often before suitable forage plants have begun growth. Problems occur in early season when animals feed on the larkspur because other green plants are not present. An important means to avoid larspur poisoning on infested range is to introduce cattle only after grass has resumed growth. Sheep may be run earlier to consume the larkspur, which also helps to save grass for cattle.

Broadleaf herbicides can also help control larkspurs in rangeland.

BOTRYTIS NECK ROT OF ONION

Botrytis neck rot, along with purple blotch, are serious fungus diseases of onions in storage. Under conditions for the disease, near total storage losses occur, due to rotting. Bulbs may become infected in the field or in storage as the spores are spread by wind, water, on equipment, by workers, or insects.



Botrytis enters onions through wounds. Common sources of these wounds include hail, harvest injuries, foliage tip burns, topping, and inadequate curing of neck areas. Late planting and excessive use of nitrogen fertilizers contribute to problems by delaying maturity of the crop.

Various controls are important in reducing losses to botrytis neck rot. Cull piles should be covered with

soil to prevent production of spores that can infect the crop. Fields should be rotated, preferably on a 3-4 year cycle, to allow elimination of infected crop debris. Neck areas should be allowed to cure properly before topping. Late season applications of fungicides may also help to protect the neck area from infections.

During harvest bulbs should be carefully lifted and handled to avoid bruising and only undamaged bulbs should be stored. Stored onions should not be exposed to direct sunlight or freezing temperatures. Good air circulation can help prevent disease development in storages.

PHYTOPHTHORA ROOT ROT

Root rot problems caused by Phytophthora fungi can be serious problems in production of many vegetables tomatoes, peppers, squash and melons. Phytophthora fungi also cause rot and crown rot problems in orchards. Most plant damage is caused when the fungus infects and girdles plants at or below the crown area. Vegetable plants may wilt and die. Infected fruit trees show symptoms associated with reduced vigor, such as poor growth and discoloration of leaves.

Phytophthora root rots occur during conditions of poor soil drainage and are particularly frequent on heavy clay soils. Growing vegetables in raised plant beds can help improve drainage and reduce infections. Irrigation of fruit trees should not be done in a manner that allows prolonged wetting of the crown area. Resistant varieties of vegetables and resistant rootstocks should be considered for use where heavy soils make Phytophthora problems common. In vegetables, crop rotations to non-susceptible crops, such as corn and grain, should be used to eliminate sources of the disease organism.

Recently, systemic fungicides (metalaxyl) that can effectively control Phytophthora have been developed. Registrations do not currently exist for all crops damaged by Phytophthora in Colorado. Contact County Cooperative Extension offices regarding labelling for these products.

CORN STALK ROTS

Corn stalk rots occur by invasion of the plant by various types of fungi. Infected plants may die prematurely, reducing yields. Lodging is commonly associated with the disease. The fungi may also produce toxins that are injurious to livestock.

Infection may occur through invasion of the roots or at nodes. Invasion of the roots is particularly common if cool, moist conditions occur following planting. Insect wounds, such as produced by corn rootworm larvae

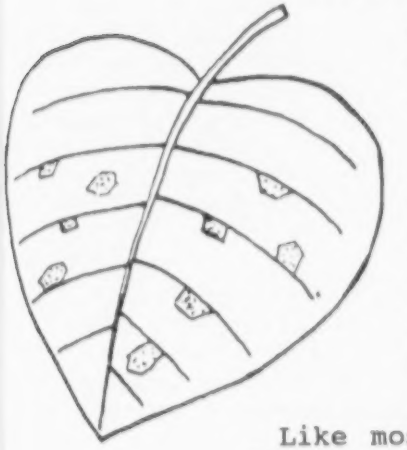
are another means of plant entry.

Unfavorable growing conditions, which create stresses on the corn plant, are very important in the development of serious corn stalk rot problems. By correcting fertility imbalances, maintaining optimal plant populations, and providing adequate moisture, problems can be minimized. This is particularly important after pollination and during early grain fill when the plants are most susceptible to infection. Although no varieties are immune to the disease, varietal differences to corn stalk rots exist.

Certain crop rotations and plowing can help reduce the amount of infected plant debris in a field.

COMMON BACTERIAL BLIGHT OF BEANS

Common bacterial blight and halo blight are two bacterial disease production problems in Colorado beans. damage to plants varies depending on what plant tissues are infected. Infections on leaves kill areas of plant tissues and extensive leaf infection can reduce yields. Infections on stems can form watersoaked cankers that can cause plants to break. Pods that are infected cause seeds to become shriveled, discolored or rot.



The disease organism overwinters on infected plant debris and in seeds. Use of certified, disease-free seed is important in managing the disease. Fields should also be rotated, preferably in a minimum 3-year rotation. (This practice also helps reduce other common bean problems such as white mold and root rots.) Some varieties of beans have resistance to this organism.

Like most bacterial diseases, common bean blight is favored by warm moist conditions. Problems increase where beans are grown under overhead irrigation rather than in furrow irrigated fields. Where problems develop, use of certain copper fungicides can help manage the disease.

FIRE BLIGHT

Fire blight is the most serious disease affecting pear, apple and related plants in the rose family. The disease organism kills the inner bark of trees causing terminal shoots and foliage to suddenly wilt and die. As the disease progresses, extensive areas of the tree can be killed.

The bacteria enter the plant through wounds, flowers, and during pruning. Spread can occur by water splashing,

human activities and by pollinating insects. Once inside the tree, development of the bacteria can be rapid if warm, moist conditions exist. During active periods of disease development, the bacteria exude from the damaged cankers that they produce on trunks and branches.

Pruning at least 15-18 inches below visible cankers is the only means to manage the disease in infected trees. Pruning should be done during the dormant season, carefully sterilizing pruning tools between cuts, and the infected wood should be removed and destroyed. Preventive sprays of fixed copper or the antibiotic streptomycin can be used during periods favoring new infections.

BARLEY YELLOW DWARF

Barley yellow dwarf is a virus disease of most cereal crops in Colorado, including wheat and barley. Infected plants are stunted, generally discolored yellow, and yield poorly if at all. Young plants may be killed.

Barley yellow dwarf is spread by aphids. Greenbug, bird cherry oat aphid, English grain aphid, and corn leaf aphid are common species of aphids in Colorado which transmit the various strains of the disease organism. There is often an increase in the disease where Russian wheat aphid occurs, perhaps due to favoring the populations of other aphids that are also protected by leaf curling. The disease is maintained in corn, on perennial grasses, and other grassy weeds as well as in grain crops.

Barley yellow dwarf management can be difficult. Insecticides used to control aphids that transmit the disease are often useful but generally not economically practical. Location of plantings distant from infection sources and delaying fall planting can also help reduce disease incidence.

RUSSIAN WHEAT APHID

The Russian wheat aphid is a new insect pest being first identified in Colorado during 1986. Since that time it has spread extensively throughout the state and has caused severe losses to wheat and barley. Insecticide treatment of the insect has also caused extensive bird kills.

Unlike most other aphids found on small grains, the Russian wheat aphid produces saliva that is toxic to the plant. This toxic saliva causes chlorophyll to be destroyed, producing distinctive symptoms of leaf streaking. Infected leaves often curl tightly preventing normal seed head emergence. The leaf curling habit also protects the aphids from predatory insects such as

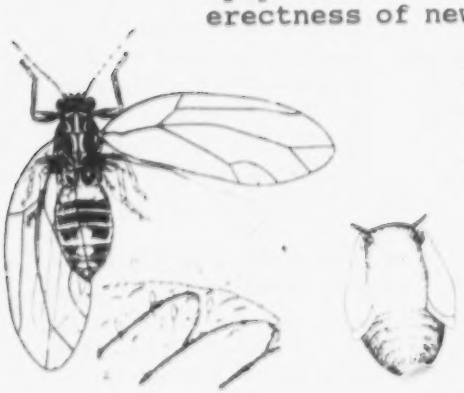
ladybird beetles. Surveys of the insect are most easily made by watching for the presence of tillers showing symptoms.

The biology and habits of the Russian wheat aphid as a pest in Colorado are still poorly understood but are being intensively studied. Damage to winter wheat seems to be greatest on drought stressed plants. Dry winter conditions appear to favor overwintering survival of the insect. Among spring seeded small grains, barley is a superior plant for the development of the aphid.

Economic levels for treating the insect vary depending upon the growth stage of the crop. Because of continuous new research developments with this insect, grain growers should check with county Cooperative Extension offices regarding latest recommendations for control.

POTATO PSYLLID

Potato psyllid damages potato and tomato plants by injecting a toxic saliva during feeding. This toxin apparently moves systemically in the plant and has properties similar to plant growth regulators. Foliar symptoms on infested plants often include stunting, erectness of new growth, and color changes. Potato tuber set can be disrupted causing the plant to produce numerous rough tubers that fail to size. Alternatively, tubers may sprout prematurely. On tomatoes, fruit can be greatly reduced in size and quality. Following control of the insect there is some recovery of infested plants.



The potato psyllid does not overwinter in Colorado and infestations are dependent upon annual migration flights. Once present in a field the insect continuously reproduces, completing its life cycle in 3-4 weeks. Problems are irregular but more common in eastern Colorado than in other production areas of the state. It is suggested that fields be regularly surveyed with a sweep net to detect adult insects as they first enter a field.

ALFALFA WEEVIL

Alfalfa weevil is the most serious insect pest of alfalfa in Colorado. Damage is caused by the immature "grubs" which chew on the first cutting hay, reducing yields and quality. Less commonly, the insects may be present in sufficient numbers to chew upon and delay the regrowth of the second cutting hay.

Alfalfa weevils overwinter in the adult stage in protected areas around field edges. They return to the

field in spring, inserting their eggs into developing shoots. The larvae feed for several weeks before becoming full-grown, at which time they drop from the plant and pupate. The emerging adults feed a little upon plants but do not cause yield reductions. There is only one generation per year.

Treatments for control of alfalfa weevil have caused extensive losses of honeybees. Also, problems with pea aphids can increase following alfalfa weevil sprays on varieties which are not resistant to pea aphids. The Colorado Department of Agriculture has released numberous parasites of the alfalfa weevil, several of which have become established.

TWO-SPOTTED SPIDER MITE

The two spotted spider mite is a serious pest problem on a wide variety of Colorado crops including greenhouse crops, fruit, beans and field corn. The mites damage the plants by sucking the cell contents from leaves causing areas of the leaf to die. During heavy infestations leaves can look scorched and die or drop prematurely.

Outdoors, two-spotted spider mites overwinter as full-grown females and often take on a red color. Populations indoors cycle continuously. During warm temperatures, particularly when dry conditions also exist, development of the mite is greatest and growth can be completed in as little as a week. Because of this ability to rapidly grow and reproduce, populations can explode in a short period.

Two-spotted spider mite can be very difficult to manage since it has developed resistance to most pesticides used for its control. Some biological controls naturally occur on outdoor crops which can be effective if not disrupted by treatments used against other pests such as codling moth and European corn borer. Indoors, some successful use has been made of introduced predators of the two-spotted spider mite.

Water management can also assist with problems. Overhead watering can wash off and destroy many mites. Prevention of drought stress on plants can also reduce development of the mites.

CODLING MOTH

Codling moth is generally the most serious insect pest of apple and pear in Colorado. Damage is produced by the larval stage which tunnels into the fruit-the common "apple worm". The adult stage is a small, grey moth with a copper spot on the wing tips.

The insect overwinters in a cocoon on the bark of the

tree or on debris in the vicinity of the trees. The adult moths emerge shortly after petal fall, mate, and the females lay eggs on leaves. The young larvae may feed upon leaves but then move to developing fruit, usually entering the calyx end. After completing feeding, they drop from the fruit and pupate.

Moths of the second generation fly in July and lay eggs directly on the fruit. The larvae tunnel into the fruit shortly after hatch. Most fruit injuries are typically caused by these second generation larvae. After they have completed development, a third generation may occur in August.

Codling moth control primarily involves the use of protective cover sprays of insecticides. These sprays are applied during periods when moths are laying eggs and eggs are hatching. The use of pheromone traps, containing the sex attractant of the insect, can help to more efficiently time codling moth sprays.

GREENHOUSE WHITEFLY

Greenhouse whitefly is a serious pest of many greenhouse crops and occasionally develops damaging populations in transplanted vegetables grown outdoors. Damage is caused by the insect removing sap during feeding and from the sticky honeydew which it excretes onto lower leaves.

The greenhouse whitefly can not overwinter outdoors in Colorado and infestations are maintained on indoor plants. Continuous, overlapping generations of the the insect occur, completed in about a month. Egg laying adult insects can then live for a month or more.

By scheduling greenhouse plantings to provide for host-free periods of 2-3 weeks, the life cycle of the insect can be broken. New plants moved into uninfested greenhouses should be carefully checked for the presence of the insects and maintained in temporary quarantine. The immature stages of the greenhouse whitefly are particularly difficult to see, being pale colored and scale-like, on lower leaf surfaces.

Insecticides, primarily those in the pyrethroid family, are used for managing whitefly problems. Repeated applications are required since the egg and non-feeding "pupal" stages are resistant to control. Yellow sticky traps are also used to monitor and even control the greenhouse whitefly, which is attracted to yellow. In warm temperature greenhouses, exceeding average temperatures of 75 degrees, an introduced parasite (Encarsia formosa) may help control the insect.

COMMON CATTLE GRUB

The common cattle grub, or "heel fly" is often the most serious insect pest of cattle in Colorado. Immature stages of this insect develop as parasites inside cattle, reducing weight gains and milk production. In slaughtered animals, the cattle grubs cause significant losses because carcasses need to be trimmed and holes are produced in hides.

The adult flies lay eggs on the legs and lower areas of the cattle during spring. The wing buzzing of the "heel flies" is often very disruptive to the cattle which may run wildly in escape. The unsettling of cattle feeding and behavior is another indirect injury caused by the common cattle grub.

The larvae of the grubs hatch from the eggs in 3 to 5 days, migrate down the hair and penetrate the skin. After this time they move through the animal, ultimately locating underneath the skin of the back where they form a cyst. After becoming full grown, they emerge through the skin, drop to the ground and pupate. There is one generation per year.

Cattle grubs are controlled by use of certain insecticides which can enter the animal systemically and kill the developing grubs. These treatments are sprayed, poured on the back of the animal, or prepared as dips. The timing of the treatments is important since problems can occur if grubs die in sensitive areas such as the esophagous or spinal cord. Milk producing dairy animals and animals that will be slaughtered before the required minimum interval after application has elapsed can not be treated with systemic insecticides.

RICHARDSON GROUND SQUIRREL

Richardson ground squirrels occur throughout most of Colorado, including the higher elevations. They are usually observed close to their mounded burrow openings and tend to occur in small family or colony groups. Under favorable conditions, populations of the ground squirrels may increase rapidly as they can produce annual litters of a dozen or more.

Planted or growing grain and forage crops are all food for Richardson ground squirrels. Where they are numerous, crops can be extensively damaged. Burrowing may also cause problems in irrigated areas.

Populations of Richardson ground squirrels fluctuate rapidly. Infestations may be virtually wiped out due to disease. Natural enemies also include hawks, weasels, badgers, and man.

Four methods of control have been practiced successfully: poisoning, trapping, fumigation and shooting. Use of poisoned grain is the most common and effective method used on farms and ranches. For large areas with numerous animals, it is the only practical control method.

Poisoned oats or barley are cheap and effective for control. Oats in particular are favored by the animals. Grass seed and cracked wheat should not be used since seed-eating birds may feed on these materials. Timing treatments is important for the effectiveness of the control. Do not make applications at the first sign of activity in spring nor in late summer when the squirrels start to disappear into burrows. Also there are periods when the squirrels may feed selectively on individual grains, eating kernals after removing the treated hull. Poisoned grain is best applied during periods when the entire colony is active and grain baits are readily accepted, particularly when squirrels are "pouching", i.e., gathering seeds for storage.

Poisoned grain should be scattered on the hard bare ground close to the cleared surface of squirrel runways. Grain should not be piled nor placed in the burrow. Bait stations may be constructed which make the bait inaccessible to other species of wildife. Poisoned grain should be handled and placed with care at all times to avoid the poisoning of seed-eating birds, pets, livestock, and young children. DO NOT REMOVE POISONED BAIT FROM ORIGINAL CONTAINERS WHEN STORING.

PRAIRIE DOGS

Various species of prairie dogs occur throughout Colorado including the black-tailed prairie dog of the eastern plains, the Gunnison prairie dog in the southwest, and the white-tailed prairie dog in the northwest. They are considered by many to be pest species since they reduce available forage around the area of the colony. The holes and mounding produced by prairie dogs also can be a hazard to livestock and equipment. Prairie dogs, and many other rodents, may also harbor fleas that transmit bubonic plague.

However, losses of forage by prairie dogs are often minimal and sometimes rangeland quality has been found to be improved by prairie dog activities. Furthermore, prairie dogs are important to a variety of wildlife which feed upon them or use their burrows for protection. Densities of prairie dogs in colonies typically range from 5-20 per acre, increasing during spring after the young pups are born in April or May.

Prairie dog eradication typically involves the use of poison baits and fumigant gases. Because of the hazards associated with the use of these poisons-to both the applicator and non-target wildlife-regulations have become increasingly restrictive. The Division of Wildlife, county Cooperative Extension offices, or the Colorado Department of Agriculture, Bureau of Rodent Control can provide information on latest regulations.

Use of poison oat baits for prairie dog control is best done during periods when green food is not available. Late summer, fall or early winter are usually the best time to begin a poisoning program. Prebaiting the area with untreated oats will increase later acceptance of the poison bait by the prairie dogs. Pre-baiting should occur for a minimum of 2-3 days before baiting with poisoned oats. When doing the actual baiting, treat the entire colony at one time. Repeat the application 7-10 days later.

Poison baits (about 1 Tbsp/hole) should be thinly scattered at the edge of the mound where the soil and grass meet. By scattering the grain, there is less liklihood that desirable wildlife or livestock will eat the grain. Whenever possible, livestock should be removed from the treatment area.

Fumigants are used when additional control is required. Because fumigants are expensive and highly hazardous, their use should be limited to only small acreages after use of poison baits. Fumigants should not be applied to burrows used by desirable wildlife such as burrowing owls.

A pre-treatment survey for the presence of black-footed ferrets is required before poisoning prairie dogs. The black-footed ferret is a highly endangered species that can be killed during prairie dog poisoning. Information on the possible location of any black-footed ferrets should be reported immediately to the Colorado Division of Wildlife or to the U.S. Fish and Wildlife Service.

STORED GRAIN INSECTS

Several insects commonly infest stored grain in storage. These include primary pests, which attack intact kernals, and secondary pests which feed on broken or cracked grain. In addition, there are several insects that feed on fungi associated with grain molds. The most common primary pests include the lesser grain borer, granary weevil, and Indianmeal moth. The sawtoothed grain beetle, flat grain beetle, and flour beetles are examples of common secondary pests.

Stored grain insects can cause several types of injuries and losses. **Direct feeding injuries** result in reductions of weight, nutritional value, and germination. **Deterioration injuries** may occur, particularly when insect feeding helps to create conditions for storage molds to develop. Sometimes the greatest injury is the mere presence of the insect or **contamination** of the grain which can result in serious dockage. This latter issue has become increasingly important as strict new grain standards for insect infestation have recently been enacted.

Fortunately, winter conditions in Colorado are sufficiently cool to prevent serious losses during the first storage season. Further losses can be prevented if the proper precautions are taken when storing grain. These may include:

1. Keep storage bins and grain handling equipment clean;
2. Maintain the storage area in good repair;
3. Use residual sprays on bin surfaces after cleaning and before storing new grain;
4. Store only clean, dry grain;
5. Properly aerate the grain to maintain uniform temperatures and prevent condensation;
6. Use grain protectants as the grain is being moved into storage;
7. Inspect grain regularly to detect developing infestations.

Where developing insect problems are detected, a few alternatives may be considered. Grain can be removed and retreated with a protectant insecticide. When the grain is removed during very cold periods, some insects may also be killed by the handling and temperature. Infested grain may also be fed to livestock. A final option is to fumigate the grain.

Grain fumigation involves the use of highly toxic gases. Fumigation of stored grain requires the use of specialized equipment (discussed later) and special protective measures for the applicator. All entrances of grain storages being fumigated must be placarded. Furthermore, fumigated grain must be aerated and handled carefully to insure dispersal of residues. It is safer and often easier to allow fumigation professionals to handle grain fumigation rather than attempting on-farm fumigation.

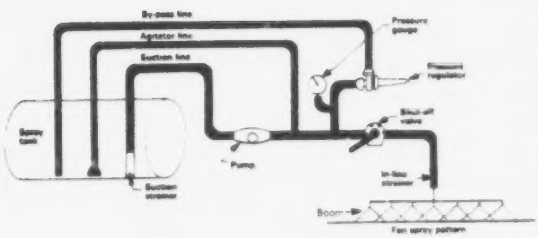
APPLICATION EQUIPMENT

The extensive use of pesticides requires the proper use and care of application equipment. The amount of pesticide used, how efficiently it controls the pest species, safety to the environment and applicator are all affected by the application equipment that is used. At present, a wide variety of different equipment is available, each with advantages and limitations in their selection and use.

SPRAYERS

Tanks

Tanks used to apply pesticides should be constructed with materials that resist corrosion. Fiberglass and stainless steel tanks are very corrosion resistant to most chemicals. Plastic coated tanks are also corrosion resistant to most agricultural chemicals. However, durability of these tanks is reduced if cracks or chips in the coating develop which expose the base metal to corrosion. Untreated metal can be used for applying non-corrosive solutions but precautions should be taken to prevent rust and scale. All tanks should be of sturdy construction to prevent leaking and rupture.



Regardless of the construction used, sprayer tanks should be designed in a manner that allows for ease in inspection, filling, and cleaning. A drain plug should be located in the bottom to permit complete drainage when cleaning.

Agitators

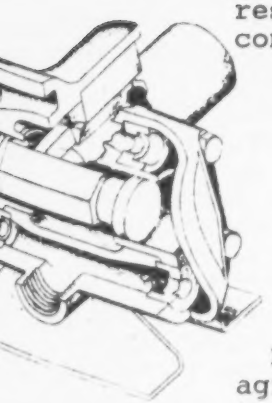
Sprayer systems should include adequate agitation in the sprayer tank to provide uniform mixing of the pesticide during application. Proper agitation is particularly important when wettable powder formulations are used that are more likely to settle to the bottom of spray mixtures unless agitated thoroughly.

Various agitation systems exist. **By-pass agitation** is accomplished by pumping excess spray material back into the tank under pressure. This system is fine for stirring solutions and emulsions, but may not adequately mix wettable powders. **Mechanical agitation** uses paddles or other devices to mechanically agitate the spray solution. Mechanical agitators can provide excellent mixing of spray mixtures but can be more expensive and difficult to maintain. **Jet agitation** uses liquids from the sprayer's pressure system. The line to the agitator in this system should be connected between the pump and

any cut-off valves to continue agitation when spraying has stopped.

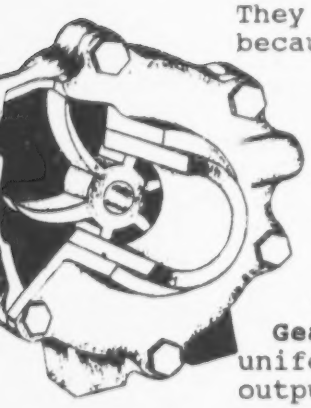
Pumps

Pumps must reliably supply the spray volumes at the pressures required for application. The selection of pumps is usually determined by considerations of cost and resistance of the pump to wear under the intended use conditions.



Piston pumps are among the most commonly used for applying agricultural chemicals. These are positive displacement pumps that are able to handle both corrosive and abrasive materials. Two types of piston pumps may be used for different application purposes: high pressure-low volume-high speed and low pressure-high volume-low speed pumps.

Roller or **roller impeller pumps** are also used in many agricultural spray systems. These pumps are adaptable to a wide range of pressures, volumes, and materials. They are accurate in the amount of spray material applied because they maintain constant pressure and flow.



Centrifugal pumps are designed to handle abrasive and coarse materials. Pumping action is achieved by use of a high speed impeller that throws the material out of the pump. It is used to spray high volumes but the maximum spraying pressures are limited to 50-60 pounds per square inch (psi).

Gear pumps are semi-positive pumps that develop uniform, moderate pressures but are limited in volume of output. They can not be used with abrasive materials.

Nozzles

Nozzles should be selected to give the proper particle size, spray pattern,, and application rate for the pressures used during application. Each nozzle is rated as to the amount of fluid that will be applied at a specified pressure and ground speed. Nozzles also are rated by the angle at which the sprayed material is discharged.

Nozzles are generally classified as to the pattern of spray that is applied. Among the more common types of nozzles are:

The **flat spray nozzle** produces a rather coarse spray in a fan-shaped pattern. Even coverage is achieved when spray areas overlap in boom sprayer applications. Flat-spray nozzles are suitable for most insect and weed

control applications where penetration of the foliage is not necessary. A wide angle nozzle with a flat spray pattern can be operated close to the ground to minimize drift.

Even spray nozzles apply a more uniform spray than does the flat spray nozzle. Even spray nozzles are useful for making band applications where there is no overlap of spray patterns from different nozzles.

Solid and **hollow cone nozzles** produce a sheet of spray in a cone shape. These nozzles are frequently used for insect or disease control since the pattern penetrates foliage well, from many directions.

The **flooding jet nozzle** is most commonly used to apply herbicides. It uses a fairly wide opening which can help reduce wear from abrasive pesticides such as wettable powder formulations. The flooding jet nozzle also operates at a low pressure, reducing the amount of drift.

Nozzle construction

Nozzles may be constructed out of many different materials. Each type of material has different characteristics in terms of resistance to wear by corrosion, abrasion, or reaction with spray mixtures. Selection of nozzle types should be made by balancing the characteristics of the different nozzle construction materials, balanced against the cost of the different nozzles.

For example, nozzles constructed out of brass are relatively inexpensive but wear quickly if exposed to abrasive materials. Aluminum nozzles resist corrosion by some spray mixtures but are readily corroded by some fertilizers. Stainless steel nozzles will not readily corrode and are better able to resist abrasion but cost substantially more than brass nozzles. Various plastic nozzles can be found which resist both corrosion and abrasion but the nozzles may swell in reaction to certain solvents used in pesticide formulations. Tungsten carbide and ceramic nozzles are most highly resistant to abrasion and corrosion but are usually the most expensive.

Strainers

Strainers or screens are placed at various points in the sprayer system to exclude foreign material that would wear out precision parts or clog the system. Screens are normally placed at the entrance to the pump intake line, in the line from the pressure regulator to the boom, and in each nozzle. Usually 25- to 50- mesh screens are used in the intake hose, 50- to 100- mesh screens are used in

the boom supply, and screens the size of the nozzle tip opening are used for the nozzle. For spraying wettable powders, all screens should be 50-mesh or coarser to prevent clogging.

Pressure regulator

The pressure regulator, or relief valve, maintains the required pressure in the system. It is a spring loaded valve that opens to prevent excess pressure in the line and allows some of the solution to return to the tank. Most pressure regulators are adjustable to permit changes in the working pressure of the system.

Types of sprayers

Low-pressure sprayers are normally designed to deliver low to moderate volumes at 15-80 pounds of pressure per square inch (psi). Application is usually made through a boom equipped with nozzles. Low-pressure sprayers are used primarily for weed and insect control on row crops, pasture, and forage lands where pressures of 80 psi allow sufficient crop coverage. Low-pressure sprayers are also used to apply liquid fertilizers or fertilizer-pesticide mixtures.

Low-pressure sprayers requiring low flow rates often are equipped with roller-impeller pumps. Centrifugal pumps are generally required where large flow rates are needed and when agitation of the spray mixture is required.

High-pressure sprayers are designed to deliver large volumes at high pressure. They are often similar to low-pressure sprayer systems but have a piston pump which can deliver high volume (up to 50 gallons/minute) at high pressure (up to 800 psi). Application rates of high-pressure systems are typically 200-600 gallons per acre. Sprays are usually applied with either a boom or a handgun. All components of a high pressure system must be designed and selected to withstand the high pressures.

High pressure systems are used primarily on fruit crops, vegetables, and trees for insect and disease control. High pressure systems may also be designed to wash equipment.

Air-blast sprayers use a blast of air-instead of large volumes of water-to propel the spray mixture. Nozzles deliver the spray into a high-velocity airstream generated by a powerful fan which breaks the spray into fine droplets. Air-blast sprayers are typically used on fruit trees, shade trees and for fly or mosquito control.

Air-blast sprayers provide good coverage of foliage and are lighter, use lower pressures, and easier to operate

than high-pressure sprayers. However, they are often expensive and produce fine particle sprays which drift from the target spray area. Because of problems of drift, the use of these sprayers is more limited by favorable weather conditions. Because relatively low water volumes are used, calibration is particularly critical with air-blast sprayers.

Special air-blast sprayers which have higher air velocities (120-200 mph) and lower air volumes are known as **mist blowers**. These sprayers produce a very fine spray.

Small-capacity sprayers are designed for spot treatments, home and garden pest control, small tree and nursery spraying, and for restricted areas unsuitable for larger units. Most are hand sprayers which use compressed air to pressurize the supply tank, forcing the air through a nozzle. Several types of small power sprayers are also available that deliver 1-3 gallons per minute at pressures up to 300 psi; adjustable handguns are usually used with these units, but spray booms are available on some models. Small-capacity sprayers are relatively inexpensive, simple to operate and maneuver, and easy to clean and store. Adequate agitation and screening for wettable powders, however, is a frequent problem. Since there is a direct reliance on the operator for movement across the treated area, there can be substantial variability in application rates.

Maintenance of sprayer equipment

Proper maintenance of sprayer equipment is essential to its proper performance. Several steps are involved in maintaining sprayers:

1. Use only clean water during application and cleaning.
2. Keep proper screens in place.
3. Never use a metal object for cleaning nozzles.
4. Do not lock a pump solidly to a tractor.
5. Lubricate your pump properly and fill with antifreeze or a light oil when not in use.
6. Flush a new sprayer before use.
7. Clean sprayers thoroughly after each use, when changing chemicals, or before storage. After using potent herbicides, such as 2,4-D, more extensive cleaning procedures are required to prevent possible crop injury during subsequent applications:
   a. Removal and cleaning of screens and nozzles with kerosene;
   b. Pumping of kerosene or fuel oil through the sprayer;
   c. Circulation of a cleaning solution (1 pound

of detergent in 40 gallons of water) through the bypass for 30 minutes, flushing part through the sprayer. Empty the remainder;
d. Filling the tank with water and ammonia (1 quart ammonia per 25 gallons of water). This solution should be pumped sufficiently to fill the hoses and nozzles, then left for 24 hours.
e. Emptying the sprayer and rinsing with clean water.

8. For extended periods of storage, exposed metal parts should be coated with a light oil to prevent rusting.

GRANULAR APPLICATORS

Granular applicators are designed primarily for soil applications. They range from crank-operated, spinning disc backpack units which broadcast granules, to field equipment designed for broadcast, band or drill applications of granular pesticides. Granules are normally applied before or at planting and worked into the soil. Post-plant side dress applications made during cultivation through drop tubes and fertilizer shoes are another common method of granular application. Granules are also applied by air, such as for control of first generation European corn borer, which develops within whorl leaves of corn.

Construction — Most granular applicators consist of a hopper for the pesticide, with a mechanical-type agitator at the base of the hopper to provide efficient and continuous feeding. Some type of metering device, usually a slit-type gate, is used to regulate the flow of the granules. Metering devices typically consist of a dial with a set-screw, or an adjustable lever with a large dial. The granules flow out through gravity feed.

Spreader — Drop-through spreaders attached to the ends of drop tubes are available in relatively narrow widths (1 1/2-3 feet). On band applicators, the height of the spreader also can be used to change the width of the band. Rotary spreaders, which distribute the granules to the front and sides of the spreader, can be used to spread granules over a wider swath.

In selecting a granular applicator, choose a unit that is easy to clean and fill. Be certain that it has good agitation over the outlet holes. Banders should spread the granules uniformly, even on side slopes of 10-15%. chain drives should have sprockets of eight or more teeth to keep drive speed uniform. Design should be that granule flow stops when the drive stops, even if outlets are not closed.

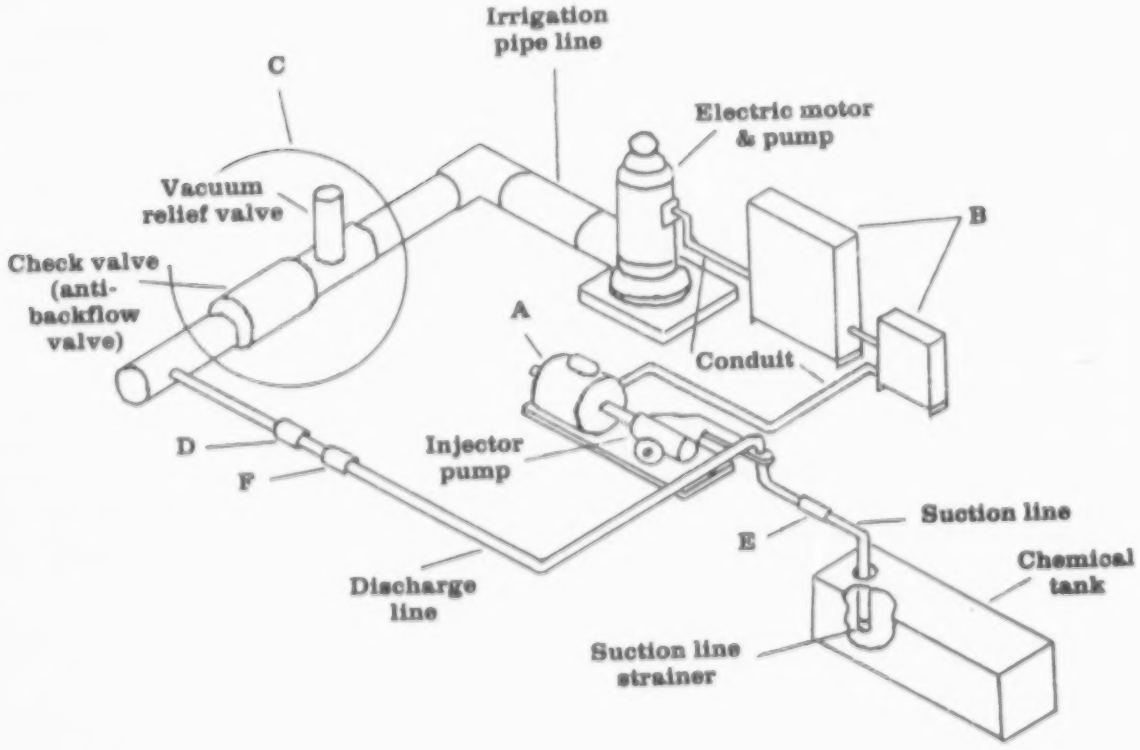
Maintenance — Granular applicators should be cleaned thoroughly after each job. Corrosion on feeder plates or the agitator can be removed with a wire brush. All fasteners should be regularly checked. Equipment should be lubricated in accordance with manufacturer specifications.

CHEMIGATION SYSTEMS

In recent years there has been a great increase in interest and in use of irrigation systems to apply both water and agricultural chemicals. This practice, commonly called chemigation, can be defined as application of an agricultural chemical by injecting it into irrigation water.

As with other methods of applying agricultural chemicals, there are both benefits and risks associated with chemigation. The most significant risk is potential contamination of the irrigation water supply. To minimize these risks, an irrigation system used to apply agricultural chemicals must be properly equipped and operated. Equipment required to apply chemicals through an irrigation system include:

- a chemical supply tank with agitator
- an injection pump
- a calibration tube
- proper safety and antipollution devices to prevent potential contamination of the water source.



Chemical supply tank

The supply tank should be constructed out of noncorrosive materials such as stainless steel, fiberglass, nylon, or polyethylene. Agitation should be provided to allow mixing of wettable powder, dry flowable, and flowable formulations and when tank mixes or other suspended formulations are used. For hard-to-mix formulations, mechanical agitators are needed.

Since some agricultural chemicals may be flammable, system design should keep the supply tank separated from sources of sparks or potential explosions. This includes use of explosion-proof electric motors and wiring, or distancing electrical motors from the supply tank. Wiring must conform with all requirements specified in the National Electrical Code for hazardous area applications.

Pumps

The proper functioning of the chemical injection pump is critical to performance of any chemigation system. Throughout the operating range of the pump an accuracy of delivery of plus or minus one percent is desirable. The pump should be easily adjusted for different injection rates. Mechanical construction should be of rugged design and use acceptably non-corrosive materials.

The injection pump capacity should be consistent with pesticide/fertilizer application rates. This can range from 1 pint or less/acre used for certain insecticides and herbicides to 30 gallon/acre for liquid fertilizer applications. With such a range, no single pump can do all jobs. It is most efficient and consistent to operate within the broad middle capacities of each pump. Avoid operating pumps at its maximum output or near its minimum output. Such usage can damage the pump and/or result in inaccurate pumping rates.

Several types of pumps are available for chemigation. **Diaphragm** pumps have been actively marketed for use in chemigation systems in recent years. Although often more expensive than other pumps they have some important advantages in use and maintenance. These include: 1) a small number of moving parts; 2) a limited area of exposure of pump components to the injected chemicals; and 3) design which allows for easy adjustment of injection rate.

Piston pumps were among the first used in chemigation systems. Calibration of these units requires that stroke length be adjusted mechanically, often while the pump is stopped. As such, calibration of equipment can take relatively more time than with diaphragm pumps. Piston pumps may also show accelerated wear of pump seals

increasing risks associated with leakage and maintenance. Among available piston pumps for chemigation, there is a range in design to help limit these problems.

The relatively low cost **venturi** "pumps" draw the chemical by creating differential pressure or vacuum across a venturi device. Obtaining accurate and consistent rates of chemical injection with a venturi device can be difficult. Variation in the flow rate of the chemical can cause pressures to vary, altering the rate of chemical injection.

Calibration tube

A calibration tube should be located in the line between the supply tank and the chemical injection pump. It is used to measure output of the injection unit during calibration. The calibration tube should be clear, resistant to breakage, and graduated in units of volume (pints, ounces, milliliters, etc.). To properly calibrate an injection system, it is necessary to monitor chemical injection for at least five minutes. Calibration tubes must be large enough to hold the amounts of chemical injected over that time.

Safety devices

Irrigation line check valves and vacuum relief valves are required in irrigation pipelines. They keep the chemical-water mixture from draining or siphoning back into the water supply. Both of these valves are to be located between the irrigation pump discharge and the location at which the chemical is injected into the irrigation pipeline.

The check valve must have a positive closing action and water-tight seal, and be easy to repair and maintain. The vacuum relief valve allows air into the pipeline when the water flow stops, preventing potential back-siphoning of the chemical-water mixture into the water source. These valves consitute the back-flow prevention system which must be designed to meet regulatory requirements. The valves should also be inspected before each chemigation operation.

Other chemigation safety equipment includes:

an inspection port to permit visual inspection of the check valve for leaks;

a low-pressure drain located at the lowest point of the irrigation pipeline to allow the chemical solution to drain away from the water-source/well in stances where the mainline check valve leaks slowly;

one-way interlocking between the irrigation pump and injection pump to ensure that the injection pump will stop with the irrigation pump;

a chemical injection line check valve with a minimum opening (cracking) pressure of 10 psi to prevent flow of liquids into the supply tank or from the supply tank into the irrigation line during unexpected shut-down;

a solenoid valve, normally closed, that provides a positive shutoff of chemical in the injection line if the chemical injection pump is stopped;

a chemical suction line strainer placed on the inlet end of the chemical suction line to prevent clogging of the injection pump, check valve, or other equipment.

FUMIGATION OF STORED GRAIN

Fumigation of stored grain is a highly specialized pest control practice. Because of the extreme hazard of fumigants, great care must be taken in planning and application. Furthermore, a thorough understanding of fumigation is important for it to be effective for the intended pest control. It is safer and often less expensive and more effective to hire a professional fumigator.

Safety

Two people should always work together when fumigating. Never fumigate nor enter a fumigated storage alone.

Proper safety equipment is essential. A self-contained breathing apparatus must be used. These are expensive (typically $1500 or more) and require special training in its use. However, simpler chemical cartridge-type gas masks fail to provide adequate protection when high concentrations of toxic gases exist.

Mark the treated area with warning signs at all entrances. The signs should be in place during the fumigation and remain intact until the stored grain has been thoroughly aerated to dissipate the fumigant to safe levels. Do not enter a fumigated storage until aeration has been completed. Aeration should remain on during any inspection of a fumigated grain storage.

Temperature

Grain temperature is extremely important to the effectiveness of a fumigation because it determines the speed of fumigant vaporization and pentration through the grain. Low grain temperatures (less than 50 degrees) greatly slow down the vaporization rate and subsequent movement of lethal gas concentrations to the pest

insects. Insect activity is also decreased during low temperatures, resulting in reduced kill. Extended periods are needed for fumigating during cool temperatures.

Moisture — Atmospheric moisture is used to release the phosgene gas from aluminum and magnesium phosphide tablets. However, high moisture grain retards the movement of the fumigant. High moisture grain absorbs more fumigant than dry grain, reducing the concentrations in the air around the kernals. Non-uniform gas concentrations can caused reduced effectiveness.

Dockage — Dockage in grain is very important in determining the effectivenss of a fumigation. The ability of the grain mass to absorb the fumigant will increase with the amount of dockage. As grain is loaded into bins, the light dockage (chaft, dust, etc.) settles around the outside of the grain mass. Heavier dockage settles around the spoutline area. This uneven distribution causes fumigants to channel through grain by flowing through areas of least resistance. In addition, insects often concentrate in areas of high dockage and therefore escape the effects of the fumigant.

Storage characteristics — The shape and depth of the grain in a bin affects the fumigant performance. Upright storages present a minimum of grain surface for the fumigant to escape. Peaks in the top of the grain surface often have lower concentrations of the gas and can allow insects to escape. Level the grain before fumigation. Also, remove or break up any crust that has formed on the grain surface.

The bin storage must be tightly sealed to allow for sufficient concentrations of the gas to occur and persist. Use of a gas-tight cover over the grain can improve fumigant performance, particularly when a bin is only partially filled.

Ventilation — Fumigants are heavier than air and sink through the grain. Penetration through the entire grain mass, especially in deep bins, can be assisted by using aeration. However, during the actual fumigation, the aeration system should be sealed off. Aeration should also be used to remove the fumigant following the recommended exposure period.

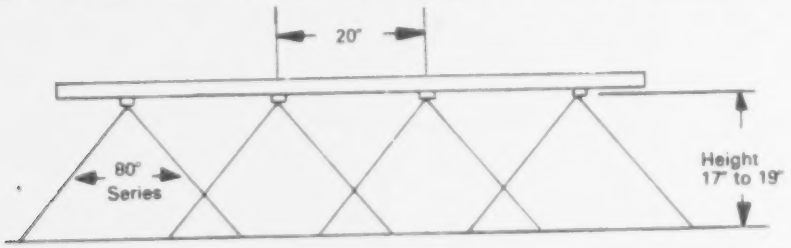
CALIBRATING APPLICATION EQUIPMENT

Proper calibration is essential to proper pesticide performance. Failure to apply sufficient pesticide may prevent control of the target pest. Excessive pesticide use rates can cause plant injury, allow excessive residues to occur on the crop, contribute to environmental contamination hazards, and cost money.

The objective of calibration is to apply the desired amount of pesticide. Calibration is relatively simple but requires time, some equipment and accurate calculations. Because conditions at worksites vary and because application system performance can vary over a season, calibration should be done regularly. Calibration should also be redone whenever replacing any components of application equipment.

CALIBRATING FIELD SPRAYERS

The application rate of pesticide mixtures used in field sprayers (including air blast sprayers) is usually given in gallons per acre (GPA). The speed at which the sprayer moves over the ground is given in miles per hour (MPH), the output of nozzles is listed in gallons per minute (GPM), and the pressure is given in pounds per square inch (psi). Ground speed, pressure, and nozzle size can all be varied to change the application rate.



NOZZLE CAPACITY CHART

Tip no.	Press. in PSI	Cap. in GPM	Gallons per acre					
			2 mph	3 mph	4 mph	5 mph	7.5 mph	10 mph
8004 (*26 GPA) (50 Mesh)	20	.28	43	28	21	16.8	11.2	8.4
	25	.32	47	31	24	18.7	12.5	9.4
	30	.35	51	34	*26	21	13.7	10.3
	40	.40	59	40	30	24	15.8	11.9
	50	.45	66	44	33	27	17.7	13.3
	60	.49	73	49	36	29	19.4	14.6

Method 1. The easiest method of calibrating the sprayer is to run it across a known area of the field or orchard to be sprayed and to measure the sprayer output. This is achieved by:

1. Determine the distance the sprayer must travel to cover 1 acre. This is accomplished by dividing the spraying width (in feet) into 43,560 (the square

feet in an acre). For example, a sprayer with a boom that is set to apply spray to an 20 foot swath would travel 2178 feet to cover an acre (43,560/20 = 2178).

2. Mark off this distance in the field to be sprayed. (Note: a fraction of this distance may be used to equal a fractional part of an acre.)

3. Prepare the sprayer and set the pressure to the level that it will be used during spraying.

4. Fill the tank with a measurable amount of water.

5. Select a ground speed that will be used during spraying and not the throttle setting so that it can be duplicated.

6. Spray over the marked course. Be precise in turning the sprayer on and off at the start and end of the course. Maintain a uniform speed.

7. Measure the amount of water that has been applied. This may be done by measuring the amount remaining in the tank or by determining the amount of water needed to refill the tank to the original level.

If a shorter (or longer) course was used representing a fraction (or multiple) of an acre, determine the refill amount in the same proportion.

If an oil solution is to be applied, and water was used during calibration, add 10% to the measured volume.

Method 2. Calibration of sprayers can also be determined by measuring the various factors involved in application rates. These include:

-gallons per minute (GPM) discharge from each nozzle;
-ground speed (MPH) of the sprayer during application;
-nozzle spacing on the boom (in inches).

With these factors, application rates can then be determined using the formula:

$$\text{Gallons per acre} = \frac{\text{5940 X Gallons per minute}}{\text{Miles per hour X Nozzle spacing (inches)}}$$

Where width of spray coverage by the boom is known this formula can be modified as:

$$\text{Gallons per acre} = \frac{\textbf{495 X Gallons per minute}}{\textbf{Miles per hour X Total width sprayed (feet)}}$$

Discharge from nozzles can be determined by measuring the amount of liquid sprayed from nozzles during a known period of time. Fill the sprayer with water and set the sprayer pressure at the level to be used in field application. Place a collecting container underneath the nozzle. **The number of cupfuls of liquid collected in 3 3/4 minutes is equivalent to the gallons per hour (GPH) output of the nozzle.**

All nozzles should be checked during this calibration and all nozzles should be applying the same rates of liquid during calibration. Where substantial deviations in nozzle output occur (greater than 5%), nozzles should be checked for wear and replaced with nozzles with output similar to others on the boom. Failure to have nozzles of consistent output will result in streaks in application pattern.

Ground speed (MPH) determinations can be made by running the sprayer along a course of known distance and using the formula:

$$\textbf{Miles per hour (MPH)} = \frac{\textbf{Distance traveled in feet}}{\textbf{1.47 X Seconds required to travel distance}}$$

Changing sprayer pressure is not a good means of changing sprayer output. This is because sprayer output only increases as the square root of the pressure increase. For example, doubling the sprayer pressure would only result in increasing output 1.4 times. Furthermore, increased sprayer pressures are often associated with increased problems with application drift.

CALIBRATING GRANULAR APPLICATORS

Several factors can greatly affect application rates of granular applicators, requiring regular recalibration. No applicator units are identical and even seemingly minor differences can affect application rates. Wear of granular applicators can be substantial due to the abrasive characteristics of many granular pesticides, which causes an increasing rate of application. Furthermore, each pesticide-and each formulation of the pesticide-has different flow characteristics which affect

application rates. Although manufacturers will often provide guidelines for typical applicator settings, it is important to check these settings by calibration.

Recommended granular application rates of formulated pesticides are generally given in pounds per acre or ounces per thousand row feet. Herbicide and insecticide calibrations may differ slightly. Herbicides are typically applied at a constant rate per unit area (i.e., acre), so band width is critical to proper calibration. Most granular insecticides used at planting in Colorado are applied a a constant rate per length of row (i.e., oz/1000 row-ft).

Calibration of granular applicators involves the following procedure:

1. Set each applicator at the setting suggested by the manufacturer or at the setting determined by previous calibrations;
2. Fill the hoppers at least 1/2 full and run them until they all begin to feed;
3. Remove the feed tubes and attach to each hopper output a container, calibration bag, or premarked calibration tube;
4. Travel a measured distance at planting speed. Since ground speed and field conditions can substantially affect granular application rates, it is recommended that calibration be conducted in a worked field over a considerable distance;
5. Weigh and record the amount of pesticide collected in each container using an accurate scale. (Remember to subtract empty container weight.);
6. Calculate the application rate for each row.

The application rate is determined by various formulae. Insecticides, applied at rates indicated by ounces per 1000 row-ft, are calculated by:

$$\frac{1000 \times \text{ounces collected}}{\text{distance traveled (feet)}} = \text{ounces/1000 row-ft}$$

Where labelled insecticide application rates are given as pounds per acre this formula changes to:

$$\frac{43560 \times \text{pounds collected}}{\text{distance traveled (feet)} \times \text{row width (feet)}} = \text{lbs/A}$$

.

Granular herbicides are often applied as bands over the row. Where labelled application rates are expressed as ounces per 1000 row-ft the formula used is:

$$\frac{\text{1000 X ounces collected}}{\text{distance traveled (feet) X band width (feet)}} = \text{oz/1000 row-ft}$$

Herbicides application rates indicated by pounds of formulation applied per acre use the formula:

$$\frac{\text{43560 X pounds collected}}{\text{distance traveled (ft) X row width (ft) X band width (ft)}} = \text{lbs/A}$$

If the application rate of any unit is not within 5% of the recommended rate, adjust the rate setting gauge and repeat the calibration.

A method to roughly check application rates involves placement of a vertical strip of tape in each hopper. Fill the hopper in 1 lb increments. After each pound is added, level the pesticide by shaking the hopper and mark the new level. Using this method, the application rate can be checked rapidly throughout the application by simply reading the levels before and after treating a known acreage.

HANDGUN AND KNAPSACK SPRAYERS

Handgun and knapsack spraying operations, such as used in greenhouse operations, present calibration problems because "ground speed" is difficult to judge. One method is to calculate the time required to cover a measured area. By timing the period required for this spray, a gallons per hour (GPH) figure can be determined. As with other sprayers, gallons per hour can be simply determined by collecting the liquid from the nozzle for 3 3/4 minutes. The number of cupfuls collected in this time is equivalent to the Gallons per hour (GPH) output of the sprayer.

With this information, the formula to determine

$$\text{minutes required to cover 1,000 square feet} = \frac{\text{1.38 X Gallons per acre}}{\text{Gallons per hour}}$$

CALIBRATING CHEMIGATION SYSTEMS

Calibration of sprinkler chemigation equipment involves 5 basic steps:

1. determine the area (in acres) to be irrigated;
2. determine the amount of material desired per acre;
3. determine the total amount of material required for application (step 1 X step 2);
4. determine the time (in hours) that injection will require;
5. determine the injection rate in gallons per hour (step 3/step 4).

The calibration process is based on the given measurements of the irrigation system (length, end gun wetting area, etc.), some common mathematical constants and conversions, and the desired rate of chemical injection. The following calculations must be made: a) area irrigated; b) amount of chemical required; c) travel speed; d) revolution time; and e) chemical application rate.

The **area irrigated** is calculated with one of several formulas, depending on the shape of the field. Where fields are square or rectangular in form the area is simply determined by:

$$\frac{\text{length (feet) X width (feet)}}{\text{43,560 (square feet/acre)}} = \text{area (acres)}$$

Where a complete circle is involved, such as with center pivot irrigation systems the calculation for determining area is:

$$\frac{\text{3.1416 (pi) X radius (feet) X radius (feet)}}{\text{43,560}} = \text{area (acres)}$$

Determining the area irrigated becomes increasingly more complex with partial circles, and other irregular areas. In many situations involving center pivot equipment, it may be wise to leave off the end gun during chemigation and when making calibration estimations. Water patterns from end guns are easily distorted by wind and end guns may make off-target applications.

The **amount of chemical** to use per acre is indicated on product labels. By multiplying this figure by the number

of acres of area, the amount of chemical required for the chemigation operation is determined.

For moving systems, **travel speed** is a very important measurement in calibration. When calculating the irrigation system speed, the system should be running "wet" and at the speed and pressure that will be used while chemigating Two measurements, **time** and **distance** are required to determine travel speed. These can be made in either of two ways:

a) record the time necessary for the outer pivot tower to travel a premeasured distance (minimum of 50 feet); or
b) measure the distance traveled by the outer pivot tower in a preselected time (minimum 10 minutes).

The end result of either method is a **rotational travel speed** measurement in feet/minute. Be aware that a measurement error of only a few feet or few minutes can create a significant error in the entire calibration process. If the terrain is rolling, check rotational travel speed at several locations and determine an average value.

Rotational speed should be periodically checked throughout the season to account for differences in wheel track resistance due to cover, soil compaction, track depth, etc. Always recalibrate when changing speed settings.

In center pivot systems, **revolution time** needs to be calculated. This is determined by measurements of rotational travel speed (above) and cirumference of the last wheel track. Circumference is calculated by the formula:

Circumference (feet) = 2 X 3.1416 (pi) X radius (feet).

Revolution time is calculated by dividing the circumference (in feet) by the rate of travel (feet per minute).

The **chemical application rate (or gallons per hour-GPH)**, is the amount of chemical which is needed to be applied per hour of chemigation. This amount is calculated by determining the total amount of pesticide to be applied to the field (amount of pesticide applied per acre X number of acres). This figure is divided by the number of hours required to complete a full revolution of a center pivot irrigation system.

Example of calibration measurement-center pivot chemigation

The field to be chemigated has a wetted radius (length of pivot) of 1300 feet. (Note: A decision must be made whether chemigation is going to include the end gun throw distance or to shut-off the end gun during application). The area would be equivalent to:

$$\frac{3.1416 \times 1300 \times 1300}{43{,}560} = 122 \text{ acres}.$$

The pesticide is to be applied at the rate of 1 quart/acre. The total amount of chemical required for the chemigation will be:

122 (acres) X 1 qt. (use rate/acre) =122 qts. (30.5 gallons)

Measurements to determine the travel speed indicate that the outer pivot tower moved 130 feet during 20 minutes. The travel speed is

$$\frac{130 \text{ (ft)}}{20 \text{ (min)}} = 6.5 \text{ ft/minute}.$$

To determine revolution time, a calculation first has to be made to determine the circumference travelled by the last wheel track. Assuming that the radius of the last wheel track to the tower is 1280 feet (it does not include the overhang), the circumference is:

$$2 \times 3.1416 \times 1280 = 8042 \text{ feet}.$$

The revolution time is then determined by:

$$\frac{8042 \text{ (feet)}}{6.5 \text{ ft/min}} = 1247 \text{ minutes per revolution (20.6 hours/revolution)}.$$

The chemical application rate would thus be:

$$\frac{30.5 \text{ gal (amount of pesticide for field application)}}{20.6 \text{ hours (revolution time)}} = 1.48 \text{ gal/hr}.$$

The use of the calibration tube is now needed to determine at what injection pump setting this amount of chemical is being applied. By setting the pump at this setting, the calibration is completed.

PESTICIDE SELECTION QUESTIONS TO ANSWER

1. Has the problem been identified correctly?

Identification of the problem is essential to the selection of appropriate pest management techniques. Incorrect identification can greatly decrease the chances of optimizing pest control. Proper identification can prevent such problems as improper timing of treatments, inappropriate selection of pesticides, and methods of application that do not achieve best performance. Failure to properly identify problems can result in poor control of the target pest, loss of treatment costs, excessive pesticide use, and attendant problems with use of pesticides.

2. Is use of a pesticide the most cost-effective means of controlling this problem?

Often the most cost-effective means of managing a pest involves a variety of techniques, with or without the use of pesticides. Pests should always be monitored prior to pesticide applications to determine whether pest populations are at levels which justify treatment with pesticides. Natural controls often limit the development of pest problems, most noticeably of insects and mites. These controls should routinely be monitored and compensated for in pest management decisions. Cultural controls may also be more effective in controlling the pest problem than use of pesticides.

When considering pest management decisions, consider all the effects of the pest control practice. For example, often use of pesticides is the most convenient means of controlling pest in the the short term. However, the effects of an application may be of short duration if they do not integrate well with other control practices, such as biological controls, that minimize future problems.

Use of economic thresholds is very useful for helping to determine the relative costs-benefits of a pesticide application.

3. Is this the proper time to consider using a pesticide?

Most pesticides are only effective against a limited stage of the life of the pest. For example, most pre-emergence herbicides only are effective against germinating seeds and do not control weeds that have become established. Eggs and pupae of insects are commonly poorly controlled by insecticides. Insects, such as borers, also become less susceptible to control by penetrating into plant tissues where they can not be contacted by the insecticide. Many fungicides are only effective when used as protectants that prevent the fungus disease from becoming established within the plant.

Whenever possible, pesticide use should also be coordinated

(integrated) with other controls. Periods when important natural enemies of insects and mites are present on the plants may be inappropriate times to apply pesticides if natural controls are to be conserved. Use of fall applications of herbicides to control perennial weeds should allow for several weeks before fall tillage operations are intended.

4. Is the pesticide being considered registered for the intended use?

This is fundamental to any pesticide use. Only uses specified on the pesticide label are legal uses. Use of pesticides in a manner that is inconsistent with its label instructions is a violation of law.

5. Are there any pre-harvest intervals that would affect its use at this time?

Pre-harvest interval restrictions indicate the period that must elapse between the last application and harvest. For some pesticides, this can be as short as a few days. There are even some pesticide uses that can be made up to harvest. However, other pesticides have quite lengthy pre-harvest interval restrictions, some as much as 60 days or more. The purpose of the pre-harvest interval restrictions is to prevent excessive residues of pesticides from occurring on harvested products.

6. Are there any reentry interval restrictions that might affect necessary field work after application?

Reentry interval restrictions occur from use of many pesticides, particularly insecticides and miticides. These restrictions prohibit workers from reentering fields for a specified period after application. The purpose of these regulations is to limit farm worker exposure to pesticides while working in pesticide treated fields.

7. Do conditions exist at the application site that might cause the pesticide to be unusually hazardous?

Special conditions at the application site may limit the ability to safely and legally use a pesticide. Areas near habitats of endangered species of wildlife may have prohibitions on certain pesticide uses. Sites which have conditions that can cause pesticide contamination of groundwater (e.g., sandy soils, high water tables, proximity to drinking water wells, etc.) may not be suitable for use of pesticides that have high potential to leach into groundwater. Proximity of the field to human dwellings, apiaries, waterways used by wildlife, or sensitive crops are other examples of sites where extra care must be used in choosing the appropriate pesticide.

PROTECTIVE EQUIPMENT

Because pesticides can enter your body through various routes, it is essential that you wear a protective barrier of clothing. No safety recommendations cover all situations; use common sense and remember that you need to take more protective precautions as the hazard increases. **Always read the pesticide label for recommendations about the use of protective clothing or devices.** Protective clothing requirements are increasingly being included among the usage instructions of many pesticides.

Gloves

The most common means of pesticide exposure is by contamination of the hands. The single most important protective equipment for most pesticide applications is a pair of gloves. Liquidproof **gloves** (such as rubber or neoprene) used when handling pesticides or contaminated equipment greatly reduce pesticide exposure risks. Do not use gloves with fabric linings since fabrics are difficult to clean once contaminated. Never use cotton or leather gloves when handling liquid formulations or when working with pesticides diluted with water. Such gloves absorb pesticides and do not provide adequate protection. Some granular pesticides may be handled with cotton gloves, if the gloves are washed or discarded after every use. Always consult the pesticide label for directions on protective clothing.

Shirt sleeves should remain outside gloves to prevent pesticides from entering the glove. Gloves used to handle pesticides should never be used for other purpposes.

Boots

Wear lightweight **rubber boots** when handling or spraying pesticides. Avoid use of leather or canvas footgear since these absorb and retain pesticides. Make sure that trouser leggings do not tuck into boots since that may funnel pesticide sprays or chemicals into the boot.

Covering

Shield yourself with some form of protective **body covering**. Wear a long sleeved shirt and long legged trousers or a coverall type garment of closely woven fabric. An outer layer of spunbonded olefin or fabric with a soil-repellent finish offers more protection than durable press or untreated fabrics. Soil-repellent finishes can be applied by clothing manufacturers or by consumers. Alternatively, use a disposable suit designed for protection when handling hazardous materials. A second layer of clothing, made with smooth T-shirt fabric, can further help to exclude pesticides from contacting the skin. Wettable powder formulations of pesticides are more effectively excluded by protective clothing than are liquid formulations.

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Wear trousers outside your boots to prevent pesticides from getting inside. When handling pesticide concentrates or handling highly toxic pesticides, also wear a lightweight raincoat or rubber apron for added protection.

When applying pesticides use a wide-brimmed, waterproof **hat** to protect your neck as well as your eyes, mouth, and face. Your hat should not have a cloth or leather sweatband, since these materials retain pesticide residues and are difficult to clean.

Eye protection

Many pesticides are highly corrosive to eyes and eyes readily absorb pesticides into the body. Wear **goggles** or a **face shield** when there is risk of pesticides coming in contact with eyes during mixing or application. Goggles may be worn separately or in combination with a respirator.

Respirators

Some sort of respiratory protective device is essential in some pesticide handling situations. The lungs are highly absorbent of pesticides and inhalation risks can be great when handling highly toxic pesticides with volatile fumes and fumigants. **Always follow carefully any instructions given on the label regarding respiratory protective devices.** Because specific types of respiratory protective devices protect against specific chemicals and vapors, it is essential to use one of the appropriate design. It is also important that the respirator fits your face properly to insure a good seal. Long sideburns, a beard, or glasses may prevent an adequate seal.

Chemical cartridge respirators draw air through activated charcoal or a dust filter. Most harmful gases, vapors, and particulate matter are removed by the filter. This type of respirator is light weight and easy to use but does not provide eye and face protection. Chemical cartridge respirators **are not** suitable protection where toxic fumigants are being used, such as in grain storages.

Gas mask respirators cover and protect the entire face. They contain larger filters with more absorbent material than do chemical cartridge respirators. Gas mask respirators should be used when mixing or applying pesticides in poorly ventilated areas. Neither gas mask nor chemical cartridge respirators give sufficient protection in low-oxygen environments.

Gas mask respirators are also available which have a self-contained oxygen supply. Where the application site

is deficient in oxygen or where high concentrations of toxic gases are present (such as fumigants), respirators with self-contained oxygen supplies should be used.

Wearing a respirator does not eliminate the need for wearing protective clothing on other parts of the body!

Maintenance

The proper maintenance and care of respirators should include regular inspections for defects, cleaning and disinfecting, repair and proper storage. An inspection check should include tightness of connections and condition of the face piece, head bands, valves, connecting tube, and canister. Respiratory devices should be cleaned after each day's use. Prior to cleaning, any filter, cartridge, or canister should be removed. The face piece and breathing tube should be washed with warm soapy water, rinsed in fresh water to remove all traces of soap, and sanitized, if necessary. Respirators should be air dried in a clean area, separate from pesticide storage or other possible pesticide sources.

When using a respirator, the cloth filter should be changed twice a day or more often if breathing becomes difficult. Cartridges should be changed after eight hours of actual use or more often if an odor of the pesticide is detected.

Periodically, test the fit of respirators by removing the cartridges and blocking the intake while wearing the respirator.

Several factors affect the service life of respiratory protective devices. These include: the type and amount of chemical fill in a cartridge or canister, the concentration of the contaminants in the air, the breathing rate of the wearer, and the temperature and humidity. It is essential that you read carefully the manufacturer's instructions on the use and maintenance of any respirator and its parts before using it. Use only respirators approved by the National Institute of Occupational Safety and Health, the U.S. Bureau of Mines, or the U.S. Department of Agriculture.

WASHING PESTICIDE-CONTAMINATED CLOTHES

Handling clothing

If liquid concentrates of pesticides are spilled on clothing, other than rubber or neoprene gloves and unlined boots, the clothing should be discarded. **Washing will not remove enough of the pesticide to make the clothing safe to wear.** Wear rubber gloves when handling these highly contaminated clothes. (Research has shown

that clothing contaminated by "undiluted" pesticides can still contain high amounts of pesticides after 10 washing; "diluted" pesticides were largely removed after 3 washings.)

Outdoors, empty pesticide granules from cuffs and pockets. If left in clothing, granules will dissolve in the wash water and may not be removed from the clothing in the remainder of the wash cycle.

Keep items worn while applying pesticides separate from other clothing before washing. Always wear rubber gloves when handling the contaminated clothing.

Wash clothing daily when regularly applying pesticides. The longer the clothing is stored, the harder it is to remove the pesticide residues.

Washing procedures

Prerinse or presoak the clothing in a bucket or tub or by agitating in a washer and spinning out before the regular wash. Prerinsing followed by a regular wash has been found to be much more effective than washing alone in removing pesticides, especially wettable powders.

Use hot water for washing, never cold. Cool water (86 degrees F) removes much less pesticide than does warm (120 degrees F) or hot (140 degrees F) water.

Heavy duty liquid detergents should be used to remove pesticides from clothing. Where hard water conditions occur, use higher rates of detergent to get adequate cleaning action. Pre-wash cleaners can help clean pesticides from clothing. Ammonia and bleach do not effectively improve the cleaning of pesticides from clothing.

Wash a small number of items at a time, using the highest water level and longest wash time available on the washing machine.

<u>Do not dry clean pesticide contaminated clothing.</u> Dry cleaning solutions are routinely recycled. Inclusion of pesticide contaminated clothing will result in contamination of other clothes.

Laundry equipment care

After washing clothes contaminated by pesticides, run the empty washing machine through a complete cycle using detergent. Line dry pesticide contaminated clothing whenever possible. This avoids contamination of the dryer.

Always wash immediately after mixing and applying pesticides!

FIRST AID FOR PESTICIDE POISONING

Unfortunately, pesticide poisoning can and does occur. At particular risk of such poisoning are workers who load and apply pesticides. Excess pesticide exposure may also occur during handling of treated produce, during accidents, or when safety precautions are not adequately followed.

Recognize poisoning symptoms

It is important to recognize pesticide poisoning symptoms so that prompt medical care can be given before more serious injury occurs. Although symptoms of pesticide poisoning vary, some typical symptoms of mild poisoning or early symptoms of acute poisoning can include: headache, fatigue, weakness, dizziness, restlessness, nervousness, perspiration, nausea, diarrhea, loss of appetite, thirst, soreness in joints, skin irritation, eye irritation, or irritation of the nose and throat. More advanced poisoning symptoms can involve: stomach cramps, nausea, diarrhea, trembling, reduced muscle coordination, extreme weakness, mental confusion, blurred vision, difficulty in breathing, rapid pulse, flushed or yellow skin, excessive perspiration, and weeping. **When pesticide poisoning is suspected, seek immediate medical attention!**

First aid procedures may be followed while waiting for a physician or in transit to hospital facilities. **The first step to take with any poisoning is to remove the patient from further contact with the poison source.** After this is done basic first aid may be followed.

Inhalation exposure

If the victim is suffering from **inhalation of pesticides**, he should be carried immediately to fresh air. When the poisoning occurs in an enclosed space, such as a fumigated storage, DO NOT GO IN WITHOUT AN AIR-SUPPLIED RESPIRATOR. Failure to do this may result in poisoning of persons involved in rescue. Loosen all tight clothing of the victim and keep him as quiet as possible. Apply artificial respiration if breathing has stopped or is irregular. If the patient is convulsing, watch his breathing and protect him from falling and injuring himself. Keep his chin up to keep the air passage free. Prevent the victim from chilling by wrapping in blankets, but do not overheat.

Skin exposure

Where **dermal (skin) exposure of pesticides** occurs, immediately remove all contaminated clothing. Drench the victim with water (shower, hose, faucet, pond, etc.) and have them wash thoroughly with detergent or soap. Dry the victim and wrap them in a blanket to keep warm while taking them to seek medical attention.

Eye exposure

Damage from **pesticide exposure to eyes** can be very serious when corrosive pesticides are involved. It is important to wash the eye out as quickly as possible with a gentle stream of running water. Continue washing the eye for 15 minutes or more. Do not use chemicals or drugs in the rinse water since they may increase the injuries caused by certain pesticide formulations.

Ingestion

Where **ingestion of pesticides** has occurred, a decision has to be made whether or not to attempt to induce vomiting. Where highly toxic pesticides are involved, vomiting is almost always the better course of action. However, vomiting should never be induced in a person that is unconscious or in convulsions.

When corrosive poisons (strong acid or alkali) or petroleum products (kerosene, emulsified pesticides, oil, etc.) are involved in the poisoning, first aid decisions are more complex. Highly corrosive materials severely burn the mouth, throat, and esophagous and will cause additional injury when being vomited up. These poisons should be treated by attempting to neutral the poison. Petroleum products also can cause burns. However, when highly toxic pesticides are involved or when ingested pesticides are diluted, vomiting is recommended.

Ingested pesticides should also be diluted or absorbed as quickly as possible. If the patient is conscious, administer water or, preferably, milk. Various "sponges" can also be given to absorb ingested poisons. Activated charcoal is very effective as absorbing many poisons and can be mixed as a thick soup with water. A homemade absorber of poisons is a mixture of 4 tablespoons of toast (burnt black), two tablespoons of strong tea (instant ice tea will do), and two tablespoons of milk of magnesia. This latter mixture will not only absorb but also help neutralize most poisons.

First-aid kit

A well equipped first-aid kit which is always readily available can be important in handling pesticide emergencies. Such a kit can be made easily and maintained in a lunch pail, tool box, or sturdy wooden box. This kit should contain such items as:

1. a small plastic bottle of **detergent** to help wash pesticides off skin;
2. a small plastic container of **salt** to help induce vomiting;
3. a container of **baking soda** or a bottle of **milk of magnesia** to neutralize acidic chemicals that have been swallowed;
4. a plastic bottle of **lemon juice** or **vinegar** to

neutralize alkaline chemicals that have been swallowed;
5. a small package of **activated charcoal** to act as a pesticide absorber;
6. a bottle (at least one pint) of **clean water**;
7. **bandages and tape** to cover cuts and scrapes so that pesticides will not easily enter the body;
8. a **blanket**;
9. a **quarter** to help place an emergency phone call;
10. a **plastic jar** to use as a drinking glass to induce vomiting or feed activated charcoal;
11. a card with **emergency phone numbers** including the doctor, hospital, and Poison Control Center.

After administering first-aid to a poisoning victim, **immediately seek medical attention.** Bring the label of the poison to assist in treatment. When the nature of the poison is unkown, a sample of the vomit can assist the hospital in determining the type of poison involved.

MINIMIZING PESTICIDE HAZARDS

WORKER PROTECTION

Workers who apply pesticides or handle pesticide-treated produce are at particular risk of excessive pesticide exposure. Protective equipment and attention to pesticide label precautions can limit these exposure risks. In addition, certain regulations have been designed to increase the protection of workers in contact with pesticides.

DIRECT SUPERVISION

All applications of Restricted Use Pesticides must be applied by or occur under the **direct supervision** of a certified applicator. Recently, the responsibilities of "direct supervision" have been clarified by the Environmental Protection Agency. Under the current definition, a certified applicator is responsible for assuring that those working under his direct supervision are qualified to handle pesticides in general and are competent in the use of specific Restricted Use Pesticides. The certified applicator must maintain oversight of the pesticide use operation from onset to completion. The certified applicator must be aware, at all times, of hazards associated with the pesticide application. Furthermore, the certified applicator supervising a noncertified applicator must:

-determine the level of experience and knowledge of the noncertified applicator in the use of a pesticide (e.g., establish an understanding of label instructions and associated hazards;
-provided verifiable (preferably written), detailed guidance on how to conduct each pesticide use performed under "direct supervision";
-accompany the noncertified applicator to at least one site which would be typical of each type of pesticide use that the noncertified applicator performs;
-be readily accessible to the noncertified applicator (at or in near contact with the application site) should the need arise.

It is the liability of the certified applicator for any violations or accidents which are committed by a non-certified applicator under "direct supervision".

REENTRY INTERVALS

Reentry intervals have been established for all highly toxic (Category I-Danger) and moderately toxic (Category II-Warning) pesticides. The reentry interval is the <u>minimum</u> period following a pesticide application before workers may reenter and work in the pesticide treated area. Some reentry intervals have previously been

established, primarily for highly toxic insecticides. In addition to exisiting reentry intervals, the following reentry intervals have been established:

48 hours for organophosphate and n-methyl carbamate pesticides in Toxicity Category I (Highly toxic-Danger);
24 hours for all other Category I (Highly toxic-Danger) pesticides;
24 hours for organophosphate and n-methyl carbamate pesticides in Category II (Moderately toxic-Warning).

The reentry interval minimum for all other pesticides is until sprays have dried, dusts have settled, and vapors have dispersed.

Workers may not enter a treated area before sprays have dried under any circumstances. During the reentry period workers may enter the treated area if there will be no contact with treated surfaces or if requirements for early reentry are met). Requirements for early reentry workers include special training (equivalent to that required for applicator/handlers of the pesticide), personal protective equipment, and decontamination facilities must be available at the site.

Farm

On farm and forestry sites, oral warnings must be given to potentially exposed workers on the day of application and repeated on any subsequent days that the reentry interyal is in effect. When pesticides are used that have reentry intervals greater than 48 hours, warning signs must be posted from all usual points of entry into the treated area.

Nursery

At nursery sites, reentry requirements vary according to method of application. For **soil-directed applications** (from a maximum height of 12 inches) the reentry-restricted area is the treated plant or area. For **downward-directed applications** involving sprayer pressures less than 150 p.s.i. (lbs/in^2) there is an expanded reentry-restricted area (10-ft minimum around treated plants, 25-ft downwind) until sprays have settled and dried. The reentry area is restricted to the directly treated area after sprays dry. Other methods of application involve reentry restrictions to all areas that were moistened (or dusted) during application. After sprays have dried, the reentry-restricted area reverts to the treated area. **Notification of pesticide applications in nurseries is through posting of warning signs.**

Green-house

Fumigant, smoke, mist, fog and aerosol applications in greenhouses are considered to involve a reentry-restricted area of the entire enclosed area receiving the application. The reentry-restricted areas of **plant-directed applications** involve sprays applied from a height above the soil exceeding 12 inches at sprayer pressures exceeding 40 p.s.i. Reentry-restricted reas include the entire enclosed area, when ventilation occurs in the greenhouse. Where ventilation is absent, the reentry restricted area is limited to the directly treated area after sprays have dried. **Soil-directed applications**, involving either liquid or granular pesticides, involve reentry-restricted areas that are limited to the treated area. However, if the product labeling requires a handler/ applicator to use a respirator, the reentry-restricted area is the same as for plant-directed applications.

CLOSED SYSTEMS

One method of reducing pesticide exposure during mixing is the use of closed systems. These involve the use of specialized equipment that allows the pesticide to be directly mixed with the spray solution. Opening of the container is done externally, by the person mixing the solution. This prevents splashing or inhalation exposures which can occur during handling of pesticide concentrates.

WOOD PRESERVATIVES LIMITATIONS

A number of health-related concerns have been identified with pesticides used as wood preservatives. As a result, the Environmental Protection Agency has recently classified the three major wood preservatives (creosote, pentachlorophenol, inorganic arsenicals) as Restricted Use Pesticides. This is based on studies that link creosote, arsenic, and a dioxin contaminant of pentachlorophenol to cancer in humans. In addition, these products have caused gene defects (mutagenicity) in laboratory animals. Continued use of these wood preservatives is currently based on new regulations determining how these materials can be applied, where treated wood can be used, and on new labelling directed at consumers.

Applicator protec-tion

Special precautions for workers applying penta-chlorophenol require that a closed system be used for powdered, flaked, and prilled formulations. Spray applications of pentachlorophenol must be design to minimize overspray. Where visible mist occurs, workers are required to wear goggles and protective clothing that is impervious to the treatment. Exposure during pregnancy should be avoided.

Workers treating wood with arsenical wood preservatives are required to wear a respirator if the level of arsenic is unknown or exceeds a level of 10 micrograms/cubic meter of air during an 8 hour day (the Permissible Exposure Limit established by the Office of Safety and Health Administration). Applications can not leave visible surface deposits of the preservative on the wood.

Use restrictions

Wood treated with creosote and pentachlorophenol can no longer be used indoors or where there may be contamination of feed, food, drinking or irrigation water. In barns, stables, and similar sites wood that is in contact with the soil can be treated with creosote or pentachlorophenol if it is covered with a sealer (at least 1 sealer coat for pentachlorophenol, 2 coats for creosote). Sealants must also be applied if wood is likely to be exposed to body contact. Logs treated with pentachlorophenol can no longer be used for log homes.

All uses of inorganic arsenical wood preservatives are Restricted Use pesticides. An exception has been allowed for brush on treatment of these preservatives for commercial construction purposes (not for household use).

The treated wood industry has also agreed to develop and distribute Consumer Information Sheets. These sheets will convey information to consumers about treated wood uses and restrictions.

LIMITING PESTICIDE RESIDUES IN CROPS

Public concerns are high about pesticide residues appearing in crops and regulations exist to limit the amounts of these residues to non-harmful levels. Prevention of excessive pesticide residues from appearing in harvested crops is essential to the continued availability of the pesticide. Pesticide residues can be limited to legal levels by:

- following pre-harvest interval requirements of the pesticide use;
- applying pesticides only to crops listed on the label;
- applying pesticides only by methods listed on the label;
- applying pesticides at rates that do not exceed those appearing on the label use instructions.

Pre-harvest interval

The **pre-harvest interval** is a very important aspect of pesticide use. It is the minimum period that must elapse between the last application and harvest. Pre-harvest intervals are established for all pesticide uses on crops

fed to humans and livestock. Required intervals also exist for many ornamental crops. The length of the pre-harvest interval is determined following studies on the degradation of the pesticide under labelled use conditions.

The length of the pre-harvest interval varies with different pesticides. For example, the pre-harvest interval for dimethoate (Cygon) on wheat is 60 days; for ethyl parathion 15 days. Intervals for any individual pesticide may vary on different crops on which it is used. Carbaryl (Sevin) applied to apples requires that 1 day elapse between application and harvest; a 14 day pre-harvest interval exists for carbaryl on head lettuce. Pre-harvest interval requirements are listed on the pesticide label. Failure to follow these requirements by harvesting prematurely can allow for excessive pesticide residues to appear on the crop.

Site restrictions — All pesticides can only be applied to crops that are specifically included in the label instructions. Since pesticides will degrade at different rates depending on how the crop is grown, crop uses of pesticides may be defined by how the crop is produced as well as what the crop is. For example, pesticide registrations for greenhouse-grown tomatoes differ from field grown tomatoes since they are considered as separate crops. Pesticide uses for ornamental plants grown in greenhouses differ when the plants are moved to interior landscaping.

Application method — The method of pesticide application is also limited label instructions. Only allowable application methods must be used to eliminate chances for excess residues on harvested produce. For example, many pesticides can be applied to the root system of the crop but not to the foliar portion (and vice versa). Aerial application to crops may be allowed but not chemigation. Chemigation uses typically are allowed for overhead irrigation systems rather than trickle irrigation.

Application rate — Use of excessive rates of pesticides can also allow harmful levels of residues to occur in a crop. In any application, only apply amounts of the pesticide equal to or less than the level indicated on label instructions. Some pesticides also have restrictions on the number of applications that can be made during a season and/or their frequency.

Ensuring that excess residues do not occur in harvested crops is a major emphasis of how pesticide labels are written. **It is violation of the law to use a pesticide in a manner that is inconsistent with its labelling.**

MANAGING PESTICIDE DRIFT

Drift control should be an important consideration during every pesticide application. Among the methods that can be used to minimize drift problems are:

-use of pesticides that have low volatility;
-use of formulations that resist drift and volatility;
-use of low pressures during spraying;
-use of nozzles which reduce formation of small spray particles;
-use of high water volumes during application;
-application release near the crop or soil surface;
-avoidance of applications during periods of high temperatures;
-avoidance of applications during windy conditions;
-use of drift reducing adjuvants.

Pesticides vary considerably in their potential drift hazard. Potent pesticides, such as the herbicides 2,4-D, dicamba (Banvel), and picloram (Tordon), can severely affect sensitive crops exposed to very low rates of the pesticides. These chemicals are inherently hazardous and their use near sensitive crops should be avoided whenever possible.

Formulation of the pesticide can reduce drift. For example, low-volatile acid and amine 2,4-D formulations have less drift hazard potential than do ester formulations. Dust formulations drift much more readily than do most sprays. Granular formulations are relatively resistant to drift.

Droplet size

Droplet size of pesticides during application is extremely important in determining the potential for drift. The ability of particles to drift increase greatly as the particle size decreases (below).

Distance water droplets drift while falling 10 feet in winds of 3 miles per hour.

Droplet diameter (microns)	Particle classification	Drift distance (ft)
30	Cloud	500
100	Mist	50
200	Drizzle	16
500	Light rain	7

Spray nozzles and application equipment typically produce a wide range of droplet sizes. Applications should be made in a way that minimizes the numbers of smallest particles while still allowing for effective coverage. This can be achieved by a number of methods.

Application pressures are important in determining the types of droplets that are formed. As pressures increase, the number of fine particles also increase. Drift can be reduced by reducing sprayer pressures during application.

Nozzle construction can also affect the amounts of small particles that are formed during spraying. Nozzle tips that produce larger droplet sizes can assist in reducing drift. For example, larger nozzles can be used at lower pressures to deliver the same application volume (GPA) as smaller nozzles operated at higher pressures. Use of higher GPA applications are an alternative means of achieving adequate crop coverage with minimal pressures.

"Thickening" or "drift control" adjuvants can also be added to the spray mixture to reduce drift. These compounds can increase the percentage of larger droplets which are formed, but do not completely eliminate small droplets.

Weather

Weather conditions during application are extremely important in pesticide drift. Air movements, both horizontal and vertical, are among the more obvious factors that affect drift. Higher wind speeds carry greater amounts of applied pesticides away from the application site. Pesticides should never be applied during high wind speed conditions (greater than 10 mph). This is particularly important when wind direction is likely to move drifted pesticides onto nearby sensitive crops.

Drift may also increase during periods when warming air near the soil rises. Applications are best made during periods when air and soil temperatures are most similar, often during early morning and late evening. Application at this time minimizes vertical air movements.

If the air near the soil surface is cooler than the air above it, an "inversion" condition is said to exist. Small spray particles remain suspended in the cool air during temperature inversions, and the particles do not settle readily onto soil or plants. Later the suspended particles move out of the crop on winds and drift. Applications should be avoided during periods of

temperature inversions.

Temperature and humidity conditions can affect pesticide drift. During high temperature/low humidity conditions particles evaporate most rapidly. This evaporation causes droplet sizes to decrease and become more susceptible to drifting in winds. Volatile pesticides also evaporate more rapidly as temperatures increase. Pesticides should be applied during cooler temperatures.

Distance

Height and orientation of sprayer nozzles can also affect drift. Distance and time for spray droplets to reach the plant or soil is directly related to height of release. Sprays should be released as near the target as will permit adequate coverage. Sprays should also be oriented so that droplets are propelled downwards to reduce the distance of droplet fall.

Vapor drift of soil-applied pesticides can be reduced by properly sealing the soil after application. This often involves proper soil incorporation of the pesticides during application.

AVOIDING POLLUTION OF GROUND AND SURFACE WATERS

Pesticide applicators should be thoroughly aware of conditions that can produce contamination of surface and ground water resources. Consideration of water contamination hazards should be an important part of decisions surrounding a pesticide application. Among the potential factors that can contribute to water pollution by pesticides are:

-proximity of the treated area to surface waters;
-proximity of the treated area to drinking water wells or aquifers;
-depth of the water table at the treated site;
-presence of soil conditions at the application site that affect potential pesticide leaching into groundwaters;
-the hazard of the pesticide as potential contaminant of groundwaters;
-conditions during application that affect pesticide drift into surface waters;
-crop managment practices that minimize pesticide leaching;
-use of precautions during application to avoid leaching or direct groundwater contamination.

Ground and surface water contamination potential should be evaluated whenever determining the need, method and frequency of a pesticide application. Pesticides should only be used when and

where necessary and only in amounts adequate to control the pests. Where alternative pest controls exist with less water pollution hazard, these should be considered.

The proximity of ground and surface waters should be considered when making a decision to use a pesticide. Sites that are near rivers, streams, and other surface waters are most likely to result in contamination of surface waters. Fields with high water tables or areas near drinking water wells may have problems with groundwater contamination. Pesticides should never be applied where they might contaminate water resources.

The susceptibility of soil types to pesticide leaching should be evaluated. Lighter soils and soils low in organic matter are most commonly associated with leaching of pesticides into groundwater. Soil pH may also be a factor affecting the breakdown-and leaching potential-of a pesticide. In fields where a high potential for leaching exists, pesticide use should be avoided or limited to chemicals that resist leaching in groundwater supplies.

The inherent leaching potential of the pesticide should be known. Problems with contamination of groundwaters have been associated with use of certain compounds ("leachers") that are highly water soluble and are weakly bound to soil particles. At sensitive sites, where other conditions favor potential leaching, these pesticides should not be used.

Proper precautions should be taken during application to reduce contamination hazards. Application equipment should always be properly calibrated and maintained. Excessive application rates or spills due to poorly maintained equipment can result in high concentrations of pesticides. Pesticides should always be applied in a manner that reduces drift. Application equipment should include safety devices to minimize problems with spills and back-siphoning. This includes the installation of backflow control equipment (check valves or air gaps) on filling pipes and in chemigation systems.

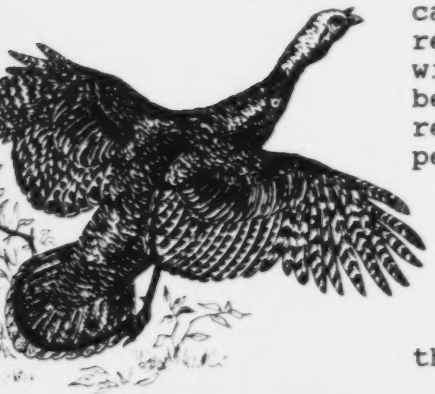
Irrigate in a manner that reduces pesticide movement. High rates of irrigation can increase the amount of pesticide leaching. Excessive irrigation can also cause run-off and erosion. Particular care should be given when irrigating shortly after a pesticide application, since the pesticide is in highest concentration at this time.

Always follow directions on the pesticide label.

Application safety instructions and certain restrictions in pesticide use are among the information on a pesticide label. It is the responsibility of the applicator to read and follow all instructions on the pesticide label. The pesticide label is a legal document and the content of the label may change as manufacturers and the EPA evaluate different uses. There are criminal and civil penalties for using pesticides in a manner that conflict with the label instructions.

REDUCING HAZARDS TO WILDLIFE

Destruction of wildlie has been an unfortunate by-product from certain pesticide uses. In some cases (e.g., DDT) these problems have resulted in the cancellation of pesticide registrations. More recently, threats to endangered species of wildlife by pesticides-and other factors-have become an important consideration in pesticide registration and use. Damage to wildlife from pesticide applications can be reduced by:



- -avoidance of pesticides that are highly toxic to wildlife;
- -use of pesticide formulations that are less hazardous to wildlife;
- -application of pesticides in a manner that minimizes damage to wildlife.

Toxicity Pesticides vary widely in their toxicity to wildlife. For example, many organophosphate insecticides are quite toxic to birds and mammals. Fish tend to be more susceptible to synthetic pyrethroid insecticides. Often, several effective pesticides may be available and the less hazardous materials can be selected.

Formulation Formulations of pesticides can affect hazards to wildlife. Bait formulations used in grasshopper control programs tend to have less severe effects on bird life than do broadcast sprays. Soil applied systemic insecticides can be less hazardous to wildlife than sprayed applications. Granules tend to be a relatively safe formulation to many types of wildlife. However, granules exposed on the soil surface, particularly colored granules, may be eaten by some animals. Surface exposed granular pesticides and pesticide treated seed have been involved in some serious bird kills.

Application Several practices during application can limit wildlife injury. Pesticides should not be applied to areas where desirable wildlife is known to be inhabiting. In some cases, such as prairie dog poisoning, pre-treatment

surveys for wildlife are required. Areas known to be frequented by threatened or endangered species of wildlife may have restrictions on certain pesticide uses as part of the Endangered Species Act.

Pesticide application timing can affect wildlife hazards. Treatments may be able to be applied during periods when migrating wildlife is not present. Delays in treatments may also be considered to allow breeding birds to rear young and disperse from the area.

During application, care should be given to reducing potential exposure of pesticides to wildlife. Soil applied pesticides or pesticide-treated seed should always be covered with soil. Attention is particularly critical when lifting equipment during field turns since granules and seed may spill and pile. Spills or puddling of insecticide spray mixtures can be very hazardous since water may attract birds and animals. Steps should also be taken to reduce pesticide drift into areas of wildlife habitat.

REDUCING LOSSES OF HONEYBEES

Honeybees commonly visit fields and orchards to collect pollen, nectar, water and other materials needed for hive maintenance. For many fruit and seed crops, the activity of these pollinators is essential to yields. In addition, the honeybee industry and honeybee by-products provide a major source of income to professional and part-time beekeepers, contributing millions of dollars in value to Colorado agriculture.

Unfortunately, pollinating insects such as honeybees often come in conflict with crop protection practices. Pesticides, particularly certain insecticides, annually kill large numbers of honeybees in Colorado, destroying or weakening colonies. For example, treatments for control of alfalfa weevil and for control of sweet corn insects often can result in extensive honeybee losses.

Steps to avoid these problems include:

- -communication and coordination with area beekeepers;
- -avoidance of treatments to crops in bloom;
- -control of flowering weeds in crops;
- -avoidance of drift;
- -use of pesticides that are least hazardous to honeybees;
- -treatment of fields during times when honeybees are not active.

Communication

Regular communication between pesticide applicators and beekeepers is a two-way process that can greatly limit honeybee poisonings. If applicators are aware of the location of colonies, beekeepers can be warned of planned applications. Colonies may then be moved or temporarily covered. Alternatively, beekeepers can block the main hive entrance and open a new entrance in the hive which disrupts honeybee foraging for several hours.

Hazard

A wide range exists in the hazard of various pesticides in honeybee poisonings. In general, relatively slow acting pesticides can be among the more hazardous to use since these pesticides may be returned to the hive and fed to many other bees. Pesticides which are readily collected by foraging bees, such as certain micro-encapsulated insecticides, are also most commonly associated with honeybee poisonings. However, formulation of pesticides can also reduce these hazards. For example, most carbaryl (Sevin) insecticides are considered highly hazardous to bees. The Sevin XLR formulation is much less hazardous since bees do not easily pick up the insecticide during foraging.

Flowering crops

Crops in bloom should not be treated with pesticides that are toxic to honeybees. Indeed, some pesticide labels (e.g. Penncap-M) prohibit the use of the pesticide on crops in bloom. This is often relatively easy to achieve where bloom occurs over a relatively limited time, such as with orchard crops. However, the presence of flowering weeds in fields or orchards may attract bees for extended periods. Weed control can therefore be an important part of honeybee poisoning protection.

Sometimes crops must be treated during periods of crop bloom because it is an essential period in crop protection. For example, the sunflower moth lays eggs during bloom and is best controlled by pesticide applications at that time. Less hazardous pesticides should be considered for these applications. In addition, pesticides can cause less honeybee poisoning if they are applied during periods when honeybees are not active. Early evening is a particularly good time to make these treatments since the spray deposits will have settled and dried before honeybees resume foraging in the morning.

Drift

Some of the most severe honeybee poisonings occur from pesticide drift. During warm periods, large numbers of honeybees may mass on the outside of the hive to help regulate hive temperatures. These exposed bees can be destroyed easily by drifting pesticides.

INTEGRATING CHEMICAL AND BIOLOGICAL CONTROLS

Biological controls can be very important in helping to control insects, mites, weeds and diseases of crops. Elimination of these beneficial organisms through pesticide use can result in control failures of certain pests and cause greater reliance on pesticides as a control tool. When possible, integration of chemical and biological controls is highly desirable and can be achieved by practices such as:

- -recognition of existing biological controls and evaluation of them before making any pesticide application;
- -use of pesticides that are less harmful to beneficial organisms;
- -timing pesticide applications so that they are less harmful to beneficial organisms.

Scouting

In a great many instances, generally unrecognized, biological control organisms effectively control pests. Even pests that regularly occur-such as spider mites on field corn, greenbugs on sorghum-may be effectively controlled under some conditions. Before making pesticide applications, fields should be examined for the activity of these biological controls. If large numbers of biological control organisms are present, pesticide uses may be deferred or avoided.

Selective pesticides

Where several different pesticides are available, selection of pesticides with less impact on biological control organisms can be made. For example, "selective" insecticides (e.g., Bacillus thuringiensis for first generation European corn borer) and miticides (Vendex for control of spider mites on fruit trees) can conserve most other biological control organisms.

Insecticides that are relatively short-lived may also be used selectively since resistant stages of the biological controls (e.g. eggs, pupae) may survive allowing fields to be rapidly recolonized. The formulation may also be important in determining selectivity. Formulations of soil-applied systemic insecticides (e.g., Disyston 15G) can be more selective than the same insecticide used in a sprayed application (e.g., Disyston 8E).

Timing

Applications of pesticides may also be timed to minimize effects on biological control organisms. For example, use of dormant sprays on fruit trees prior to flowering can control pest species that exist on the

plant at that time. Biological control organisms typically move to orchards later in the season and are little affected by dormant applications.

MANAGING PHYTOTOXICITY HAZARDS

Plant damage resulting from a pesticide application to a desirable plant is known as phytotoxicity. Most commonly, this is indicated by some burn of leaves, flowers, or growing tips. Yellowing, leaf distortions, abnormal growth and stunting are other types of phytotoxicity. Phytotoxicity is a particular concern with crops where appearance is critical to marketing (tree fruits, flowers, ornamentals).

Some types of phytotoxicity regularly are associated with the use of certain pesticides or pesticide formulations on susceptible plants. However, phytotoxicity may only irregularly occur under certain conditions. Phytotoxicity problems can be largely avoided by:

- -avoidance of pesticides on plants known to be susceptible;
- -use of formulations that have reduced phytotoxcity hazard;
- -apply pesticides under favorable environmental conditions;
- -do not use excessive rates or application frequencies;
- -avoid mixing pesticides
- -never apply insecticides and fungicides with herbicide-contaminated equipment.

Careful reading of labels can help to identify many plants that may be injured by the pesticide. These warnings may be in label sections discussing crop uses; alternatively phytotoxicity warnings may occur in separate sections of the label. These warnings may indicate that only certain varieties are susceptible to injury. Pesticides broadly labelled for use on flowers or ornamentals often may not include warning statements for some susceptible plants.

Formulation

Wettable powder and other dry formulations tend to be safer to use on sensitive plants than are emulsifiable concentrate liquids. This is because the various "inert" ingredients found in some emulsifiable concentrates (e.g. xylene) can be harmful to plants. Almost all aerosol formulations of pesticides used on ornamental plants can cause injury if used at less than the recommended distance between the spray nozzle and plant (usually 18-20 inches or more).

Weather

Avoid spraying plants during extremely hot, sunny conditions. Temperatures exceeding 90 degrees can increase injury by many insecticides. During sunny conditions, leaf and flower temperatures may be considerably warmer than air, allowing for injury at lower air temperatures.

Cool temperatures increase the plant injury of other pesticides.

Pesticides should also not be applied during periods which do not allow drying. Plants sprayed when cool humid conditions exisit will remain wet for long periods, allowing increased probability of injury. Wet foliage also increases injury by aerosol formulations. Slow drying is one reason why greenhouse grown plants are particularly sensitive to spray injuries.

Never spray plants that are in need of water. Wilted or dry plants are extremely sensitive to spray injury. Slow growing or diseased plants may also be injured more frequently than vigorously growing plants.

Mixtures/ rates

Excessive rates of pesticides can cause injury. Plants may also be injured by repeated applications made at short intervals.

Certain mixtures of two or more pesticides can cause plant injury. For example, the use of any sulfur based pesticide will cause increased injury if combined with oils. Compatibility charts exist that can help avoid many of the mixtures known to cause phtyotoxicity hazards.

Sprayer equipment used for applying herbicides should never be used for spraying insecticides and fungicides. Minute amounts of herbicide residues in such equipment can cause severe damage to desirable plants.

Testing

An important precaution for use of pesticides on flowers and ornamentals is to test the spray mixture on a few plants. Several (3-4) preliminary applications should be made, at short intervals (3-7 days) under normal growing and spraying conditions. Plant damage by some pesticides may be evident within 18 hours; others may take 3 days before injury is evident. It is useful to compare sprayed plants with adjacent non-sprayed plants receiving identical cultural care.

PESTICIDE STORAGE AND DISPOSAL

PESTICIDE STORAGE FACILITIES

Careful attention should be given to proper pesticide storage. Improper storage conditions can reduce the effectiveness of the pesticides due to breakdown from freezing, excessive temperatures, or exposure to moisture. Proper storage can reduce the chances of pesticide-related accidents and can allow for easier handling of accidents if they do occur.

A pesticide storage facility should have a concrete floor which is impermeable and easy to wash. Ideally, the structure should be fire resistant and located away from other buildings. Adequate ventilation is important to prevent exposure of the pesticides to extreme heat and to reduce the concentration of toxic or flammable vapors in the storage. Insulation and supplemental heating may also be needed to protect pesticides from freezing during cold temperatures. Many pesticides, particularly liquid emulsifiable concentrates, will separate and degrade at low temperatures. Lighting in storage facilities must be sufficient to allow for easy identification of stored materials.

Pesticide storage areas should not be used for other purposes. Pesticides should never be stored with food, feed, seed, planting stock, fertilizers, or veterinary supplies. Pesticides should also be stored separately from protective equipment such as respirators, goggles, and protective clothing. Since total decontamination of pesticide storage areas is often not possible, designated pesticide storages should not be planned for subsequent uses.

Running water and other materials needed to safely handle small-scale accidents involving pesticides should be located near storage facilities.

Proper placement of pesticides within storage areas should also be given consideration. Dry formulated pesticides should be stored on wooden pallets or metal shelves to prevent possible contact by moisture on floors. Dry materials should also not be placed under or below liquid formulations to prevent contamination in case of leaks.

If metal containers are to be stored for a prolonged period, they should also be placed on pallets to prevent potential corrosion of containers. If corrosion of containers is detected, they should be immediately repaired, if possible. When this is not feasible, the contents of the pesticide should be transferred into

another container with an intact label which has held exactly the same product.

Pesticide storage areas should always be kept locked when unattended.

Pesticide storage areas must be be clearly marked with warning signs as to the contents of the storage. These warning signs should conform to standards used to mark hazardous storage areas which assist in emergency response at the storage, such as accidents or fires.

Emergency Planning and Community Right-to-Know Act

Recently, a new federal law, the Emergency Planning and Community Right-to-Know Act (EPCRA), was passed that sets new regulations for pesticide storage. Certain pesticides have been designated as "Extremely Hazardous Substances". These include most Restricted Use pesticides and some additional materials that are considered hazardous, such as ammonia. If amounts of these chemicals are in storage and exceed the "Threshold Planning Quantity" for that pesticide this regulation goes into effect. The amount of pesticide exceeding the Threshold Planning Quantity varies from 10-10000 lbs of active ingredient, depending on the type of pesticide in storage.

Notification must be given to both state and county agencies of storages with pesticides in amounts above the Threshold Planning Quantity. State notification should be given to the Colorado Emergency Planning Commission, c/o Colorado Department of Health, 4210 E. 11th Ave., Denver CO 80220. (Phone number 303-331-4858). Local Fire and Police officials will have information on whom to contact within the county. Most County Cooperative Extension offices also have information as to Threshold Planning Quantities of various pesticides.

To notify the State and local authorities a letter such as follows is recommended:

"I am _____(name)_____ representing _____(name _____ of ____company/individual firm)_____ at _____(address)_____.

I (We) have one or more of the Extremely Hazardous Substances at or exceeding the "Threshold Planning Quantity" at (my/our) facility. The contact for my (farm/firm) is _____(name)_____. He/she can be contacted by calling _____(phone number)_____ or by writing _____(address)_____."

DISPOSAL OF PESTICIDE CONTAINERS

Pesticide containers come in many shapes and sizes and are commonly made of paper, glass, plastic, or metal. Proper methods for disposal of these containers include:

1. **Paper bags** must be thoroughly emptied and either buried on your property in a safe location away from water and susceptible animals or plants, or they may be added to other solid waste trash for ultimate sanitary landfill disposal.

2. **Solid containers** must be triple rinsed and then either buried or added to the other solid waste for sanitary landfilling. Do not let "empty" pesticide containers set for more than 12 hours before triple rinsing. Pesticide residues may solidify and stick to container surfaces under such conditions and not rinse away adequately. Mark "triple rinsed" on containers disposed of in landfills to identify them as non-hazardous waste.

The Triple Rinse Procedure

-Empty your pesticide container into the spray tank and allow the container to drain for 30 seconds;
-Add rinse water to the container until it is 1/4 full;
-Rinse the container thoroughly. Pour rinsate into spray tank and drain for 30 seconds. Repeat 3 times.
-Recycle or puncture and dispose of the triple rinsed container properly.

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3. **Plastic containers** (bottles and jugs) should be triple-rinsed, punctured, and then either buried or added to other solid waste for sanitary landfilling.

4. **Metal containers**, other than pressurized containers, must be triple-rinsed, punctured, and either buried, recycled, or added to other solid waste for sanitary landfilling. Flattening metal containers after they have been triple rinsed reduces landfill space requirements and facilitates recycling as well. Properly rinsed metal drum containers may be accepted by some reconditioners and manufacturers.

Promptly store used pesticide containers in proper pesticide storages, pending disposal. This is particularly true if containers have not been triple rinsed. Improperly stored containers may allow exposure of children, pets, and wildlife to accidental poisoning.

DO NOT send nontriple-rinsed pesticide containers to sanitary landfills, reconditioners, or recyclers.

DO NOT discard pesticide containers in unapproved locations.

DO NOT reuse pesticide containers for other purposes.

DO NOT dispose of any pesticide container in a manner that is inconsistent with its labeled directions.

DISPOSAL OF PESTICIDE WASTES

When pesticides are used there is often some associated excess pesticide or pesticide waste. Proper disposal of these wastes can be difficult and expensive. However, improper disposal of these materials can result in serious pollution or poisoning hazards. Improper disposal also subjects the applicator to substantial fines, clean-up and disposal costs.

Pre-planning and anticipating pesticide needs can allow for a reduction in pesticide wastes and reduced pesticide disposal problems. Ways to reduce production of pesticide waste should be given careful attention and include:

1. Purchase only the amount of pesticide needed to accomplish the intended pest control task or to be sufficient for a season's use.

2. Prepare only a sufficient amount of the pesticide for the intended pest control application after estimating how much will be needed to cover the intended site.

3. Protect pesticides from damage and contamination so that they remain useful products and have legible labels. Store pesticides in a cool location out of the sun in locked storages. In the winter, many liquid formulations of pesticides must be prevented from freezing or separation of contents can occur. Dry formulations must be protected form moisture.

4. Use up pesticides before they are no longer effective for the intended purpose, using older products first.

The best way to avoid pesticide waste disposal problems is to avoid creating pesticide waste!

Even planning may not eliminate the need for all pesticide disposal. Disposal methods then include:

1. Use the pesticide according to label directions as a means of disposal. This practice will not always be feasible, especially when the site of application for the pesticide is a food crop or animal or when the label limits the frequency of application to a site. Read the label and be sure that this method of disposal is appropriate for the pesticide in question.

2. Acutely hazardous wastes (Toxicity category I- LD_{50} of 50 mg/kg or less) in quantities exceeding 2.2 pounds must be disposed of in an approved hazardous waste site. Failure to properly dispose of these highly hazardous materials can be considered a pesticide spill and is subject to regulations regarding management of spilled pesticides.

3. Smaller quantities of hazardous pesticide waste (or pesticides not classified as being highly hazardous) generated by an agricultural producer can be disposed of on the property of the producer. **Such disposal must be done in a manner that prevents movement of the pesticide where environmental damage may occur.** This includes avoiding disposal near such environmentally sensitive area such as along waterways, near wells or wildlife habitats and sites that are erodable and/or may allow leaching.

PESTICIDE SPILLS

Pesticide spills can pose serious threats to human health and cause significant environmental contamination. A thorough knowledge of the appropriate steps to take in the event of a spill will allow you to minimize the potential for adverse effects and may save you a great deal of money in expensive clean-up costs. Always be prepared to handle spills before they occur. Contamination can greatly increase when delaying response to a pesticide spill.

Spills may be relatively minor, involving one or a few leaking containers. However major spills, such as when a truck or sprayer overturns spilling their contents, can and do occasionally occur. Regardless of the magnitude of the spill, the objectives of a proper response are the same. First, you must "control" the spill; second, you must "contain" the spill; third, you must "clean it up". These three steps are frequently referred to as the

"Three C" program of spill management.

Control the spill

Immediately after a spill has occurred, steps must be taken to **control** the flow of leaking pesticide. Do everything possible to stop the leak or spill at once! Leaking containers may be repacked. Leaking sprayers should be turned off immediately. Stopping large leaks or spills often is very difficult.

When attempting to control the flow of the chemical, do not expose yourself unnecessarily. Always carry protective clothing and equipment when transporting pesticides. Use this equipment when pesticide emergencies occur.

Contain the spill

After the leak has been controlled as well as the possible, **contain** the spilled material in as small an area as possible. With liquid spills, construct a dam to prevent the chemical from spreading. It is particularly important not to allow any chemical to get into any body of water, including storm sewers. **Do not hose down the area**; this will cause further spread of the chemical.

Liquid spills can be further contained by spreading absorbent materials such as fine sand, vermiculite, sawdust, or clay over the entire spill. For absorbing small spills and minor leaks, kitty litter is particularly useful. (Note: Avoid the use of sawdust or sweeping compounds if the pesticide is a strong oxidizer. Such a combination presents a possible fire hazard.)

Report the spill

Spills on public property and all spills involving pesticides that are considered to be highly hazardous **must be immediately reported to local and state emergency planning personnel**. Police or fire officials typically are local contacts to whom such spills should be reported; the State Emergency Planning Commission can be contacted at 303-331-4858 or 303-331-4830. These agencies will advise as to proper procedures for cleaning and disposing of accidentally released pesticides. Failure to report such spills is considered to be a violation of the Emergency Planning and Community Right-to-Know Act (EPCRA). Such violations can result in fines of up to $25,000 for each day the violation continues.

Accidents involving some pesticides and hazardous materials are regulated by additional legislation. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) has been in effect since 1980.

Spills involving CERCLA-regulated materials (see below) require that the National Response Center also be notified (1-800-424-8802). If you are not sure whether a spill involves regulated amounts or materials, report the spill.

SOME CERCLA-REGULATED HAZARDOUS SUBSTANCES

aldicarb (Temik)	aluminum phosphide
ammonia	dimethoate (Cygon)
disulfoton (DiSyston)	endosulfan (Thiodan, Endocide)
ethion	lindane
methomyl (Lannate)	mevinphos (Phosdrin, Vegephos)
nicotine	ethyl parathion
pentachlorophenol	phorate (Thimet, Rampart)
sodium arsenite	warfarin

During major spills, someone must remain at the spill site at all times until it has been effectively contained and cleaned up. Also the contaminated area should be isolated, preferably by roping it off. Keep people at least 30 feet from the spill. Avoid coming into contact with any drift or fumes that may be released. At times it may be necessary to evacuate people downwind from the spill. Do **not** use road flares if you suspect the material to be flammable.

Clean-up the spill

During **clean up** of the spill, spread absorbent material over the contaminated area, if not done so previously. Sweep the absorbed pesticide and place it into a heavy duty plastic bag. Continue to add absorbent until all the liquid has been soaked up.

After these preliminary stages of clean up have taken place, it may be necessary to further decontaminate and neutralize the area. This is particularly recommended if highly hazardous pesticides are involved. Often a mixture of full-strength bleach and hydrated lime is effective for pesticide decontamination. Work the solution into the spill area with a coarse broom. Add absorbent material to soak up the cleaning solution. Sweep and dispose of the contaminated material. Repeat the procedure until the area is thoroughly decontaminated.

When large amounts of pesticides are spilled on soils, effective decontamination is often not possible. In these instances, the top 2-3 inches of soil should be removed. Cover the contaminated soil with at least 2

inches of lime, then cover with fresh topsoil.

Where minor spills occur to soil, activated charcoal may be used in clean up. The charcoal may absorb and tie-up enough chemical to avoid significant long-term injury.

FIRES IN PESTICIDE STORAGES

Pesticides should be stored in separate, locked buildings-away from other structures involved in the farming/ranching operation. **This includes storages of fertilizers.** For example, ammonium nitrate fertilizers can become become highly flammable when contaminated by fats, oils, acids, finely divided metals, or sulfur.

Should the pesticide storage facility be involved in a fire, the local fire authorities should be allowed the clear option to allow the facility to burn. Instances occur where extensive contaminated run-off would result from fire-fighting activities or where incomplete combustion would produce toxic compounds in the air. Allowing the pesticide facility to completely burn may be the best option in these instances.

Persons storing pesticides must mark storages with appropriate warning signs indicating storage contents. **This is an essential safety regulation designed to protect individuals responding to fires, spills, and other emergencies at the pesticide storage facility.** Growers are also required to pre-notify local fire authorities of pesticide storage contents as regulated by the Emergency Planning and Community Right-to-Know Act, discussed above.

Should fires occur in pesticide storages, individuals involved in the firefighting and cleanup should follow personal precautions:

1. Wear rubber footgear during clean-up operations. Leather or cloth footware will absorb and retain pesticides;
2. Wash and shower using large amounts of soap and water to remove any trace of toxic chemicals;
3. Put on clean clothes;
4. Wash all personal clothing, protective clothing, and respirators. Wash separately from clothing that is not pesticide contaminated.
5. **Watch for pesticide poisoning symptoms.**

Decontamination and disposal of fire damaged pesticide storage facilities is complex. This task should be undertaken in conjunction with state and local emergency reponse personnel.

A CHECKLIST FOR PREVENTING PESTICIDE ACCIDENTS

Everyone can improve their methods for safe handling of pesticides. Even experienced pesticide applicators may become so familiar with the equipment and materials used that they become careless or take shortcuts. Then an accident can happen.

The following checklist of questions is drawn from data showing the common causes of pesticide accidents. Check it against your pesticide handling practices and see how many accidents are waiting to happen to you. Just one "No" may be the one that gets you in trouble!

Store Your Pesticides Safely

____ Do you have a separate space to store pesticides?
____ Do you keep it locked and are the windows tight, barred, or boarded over?
____ Do you keep all your pesticides in this storage rather than in the garage, feed room, basement, porch, or other areas?
____ Do you store herbicides separately from other pesticides?
____ Are there warning signs on your storage so firemen and others are warned?
____ Have you notified state and local emergency preparedness authorities of locations of pesticide storages containing threshold reportable quantities of hazardous materials?
____ Do you check periodically for leaking containers or other problems in the storage?

Keep The Original Container So The Label Is There!

____ Do you always keep pesticides in the original container?
____ When people ask you for a little spray mix out of your tank, do you refuse?
____ Do you always remember the safety precautions, antidotes, and directions for use, even though the container is not labelled?
____ Do you safely dispose of unlabeled pesticides, rather than take a chance with memory?

Use The Recommended Clothing And Protective Equipment!

____ Do you read the label to see what protective clothing you should wear?
____ Do you start each spraying day with clean spray clothing?
____ Do you check the signal words and precautions for use on the label to see what protective equipment is necessary?
____ Do you wear the protective equipment recommended on the label?
____ Do you clean and maintain your protective equipment regularly and often?

____ Do you throw away rubber gloves that have only tiny holes in them?
____ When fumigating stored grain, do you use a self-contained breathing apparatus?
____ Do you regularly test the fit of your respirator before using it to apply a pesticide?
____ Are the clothing and footwear used during mixing and application of pesticides made of pesticide repellent materials?
____ Is protective equipment cleaned and washed after every use?
____ Do you sometimes enter a fumigated storage alone?

Spills And Splashes Of Concentrates Can Be Very Hazardous!

____ Do you know what to do if you should spill a pesticide on yourself while mixing?
____ Do you wear adequate footgear with your pant cuffs on the outside so pesticides won't run into your footgear?
____ Do you have sawdust, vermiculite, kitty litter, or some other absorbent on hand to soak up spills?
____ Do you always watch your sprayer tank when filling so it won't run over and spill on the ground?
____ Do you have a check valve or other device on the equipment to prevent back-siphoning into the water supply?
____ Is your application equipment well-maintained so it does not leak and leave puddles of spray mixture or piles of pesticide granules?
____ Do you avoid draining leftover spray mix on the ground?
____ Do you discard old high pressure hose instead of patching it and hoping that no one will be nearby when it bursts?
____ Do you clean nozzles with a brush, by rinsing, etc. instead of blowing them out with your mouth?
____ Do you always wash immediately after mixing and applying pesticides?

Poor Container Disposal May Cause Bad Accidents!

____ Do you rinse each "empty" liquid container at least three times and dump the rinsings into the tank?
____ Do you keep your used containers in your storage area until disposed?
____ Do you collect every container for disposal before leaving a job instead of leaving them in the field or at your tank filling station?
____ Do you puncture, break, or crush non-burnable containers so they can't be reused?
____ Do you keep or return to the manufacturer 30 and 55 gallon pesticide drums rather than giving them away for floats, trash barrels, etc.?

Attractive Nuisances Can Result In Lawsuits!

____ Do you keep your spray equipment where children can not play on it?
____ Do you keep your spray equipment clean so that those touching it will not be contaminated?
____ Do you always release pressure on your equipment so spray guns won't be accidentally triggered?
____ Are fumigated storages always marked with warning signs at all entrances?

Care In Application Prevents Accidents

____ Do you check the wind direction and the area downwind before applying pesticides?
____ Do you consider subsituting a safer chemical if you are spraying near a sensitive area?
____ Do you check for the possibility of showers and damaging run-off before applying pesticides?
____ Do you turn off the end gun when chemigating if spray is likely to drift onto non-target areas?
____ Do you know whether the pesticide you are considering to use is highly leachable pesticides and might require extra pre-caution in use under conditions that favor leaching into groundwater?
____ Do you always delay spraying during periods when high winds will cause excessive drift from an application?
____ Do you always delay applications of volatile herbicides when temperatures exceed 85-90 degrees?
____ Do you plan a pesticide application so that it will have little or no effect on bees, birds, fish, or other wildlife?
____ When poisoning prairie dogs, do you always do a pre-treatment survey for black-footed ferret activity?
____ Do you make sure that farmworkers, children, and pets stay out of pesticide treated areas until after sprays have dried and/or after the required reentry interval has passed?
____ Does your chemigation equipment include all necessary anti-pollution and safety devices and do you regularly inspect and maintain them?
____ When supervising a non-certified applicator, do you always ensure that the person is qualified to handle pesticides in general and competent in the use of Restricted Use pesticides?
____ When supervising a non-certified applicator, do you maintain adequate supervision of a pesticide use operation from onset to completion?

ALWAYS READ THE LABEL BEFORE ANY PESTICIDE USE!

GLOSSARY

Abrade-To scrape and break the skin or surface layer.

Abrasive-Something that has the ability to grind down or wear away an object. Example: wettable powders are abrasive to pumps and nozzles, causing them to wear quickly.

Absorb-Movement of a molecule from the surface into soil, plants, animals, animals or other objects.

Acaricide-Pesticides used to kill mites (also described as miticides).

Acid-A compound whose hydrogen atom is replaceable by positive ions or radicals to form salts. Often very sharp and sour liquids which can be highly corrosive in concentrated form.

Acre-A commonly used measure of area comprising 43,560 square feet, approximately 210-ft x 210-ft.

Activated charcoal-Very finely ground, high quality charcoal which easily absorbs liquids and gases.

Active ingredient-The ingredient (or ingredients) in a pesticide product which are considered responsible for the desired effects (e.g, destroying, repelling, or mitigating the effects of pests).

Acute poisoning-Poisoning which occurs after exposure to a pesticide after a brief period.

Adjuvant-An inert ingredient added to a pesticide formulation to increase pesticide performance (e.g., surfactants, stickers, buffers, etc.).

Adsorb-Ability to chemically hold or bind molecules. (Example: clay and organic matter soil particles tend to "bind" many pesticide molecules".)

Aerosol-Extremely fine mist or fog consisting of solid or liquid particle which readily remain suspended in air. Also used to define certain formulations or equipment used to produce fine articles.

Agitate-The process of stirring or mixing, used to describe methods to prevent pesticides from separating or settling in a spray tank.

Alkaline-Chemicals with an excess of hydroxyl ions over hydrogen ions (opposite of acid). High pH. In concentrated form, may be highly caustic, such as lye.

Anion-An ion having a negative charge.

Annual-To have a life cycle that requires one year to complete.

Antibiotic-Chemicals produced by certain organisms, such as bacteria, yeasts, and molds, which inhibit or damage susceptible cells. Most often used in agriculture to inhibit the activities of disease causing bacteria.

Attractive nuisance-A legal term used to describe any object which might attract children or other persons to it and then might injure or hurt them as a result.

Back-siphoning-Movement of fluid or spray material back to the original source through siphon action.

Bacteriacide-Any chemical used to kill bacteria.

Band application-an application to a continuous restricted area such a in or along a crop row.

Biennial-To have a life cycle that requires two years to complete.

Bioaccumulation-To collect and accumulate in living tissues.

Biological control-control of pests by means of predators, parasites, and disease producing organisms. Often the term implies some manipulation by humans.

Biomagnification-To accumulate in living tissues at increasing concentrations among organisms as you move up the food chain.

Botanical pesticide-Pesticide derived from a plant source.

Brand name-As applied to pesticide, the name of the pesticide as sold by a dealer or manufacturer to an end user.

Canker-A dead, often sunken, area on the branch, stem or trunk of a plant.

Carcinogen-A substance capable of producing cancer.

Carrier-The inert liquid or solid material added to an active ingredient to prepare a pesticide formulation.

Cation-An ion having a positive charge.

CERCLA-Acronym for the Comprehensive Environmental Response, Compensation, and Liability Act, legislation which established reporting requirements for accidents involving certain hazardous pesticides.

Chemical name-The descriptive name used to indicate the chemical compostion and chemical sturcture of a molecule.

Cholinesterase-An enzyme found in animals used to regulate the activity of nerve impulses.

Cholinesterase inhibitor-A compound which inhibits the cholinesterase and can result in disruption of normal nerve transmissions. Organophosphate and carbamate insecticides are cholinesterase inhibitors.

Chronic poisoning-Poisoning which occurs following prolonged exposure to a poison.

Commercial applicator-A certified applicator who applies pesticides for hire or as a condition of employment.

Common name-An official abbreviated name given to the active ingredients of pesticides and other chemical compounds; also, the officially designated name for a pest species.

Compatible-The ability of two or more chemicals to be mixed without affecting each other's properties.

Complete metamorphosis-the process of insect development invovling successive egg, laral, pupal, an adult stages. (Examples: moths and butterflies, beetles, flies.)

Concentration-The amount of active ingredient in a given volume or weight of formulation.

Contact pesticide-A pesticide which kills when it touches or is touched by a pest.

Corrosive-Capable of reacting with and wearing away by chemical means.

Deflocculating agent-A substance that prevents settling of solids in a spray tank.

Defoliant-A pesticide used to cause leaves to drop, usually to facilitate harvest.

Degradation-Breakdown, used to describe the process by which chemicals are reduced to simpler elements by the action of microbes, air, water, sunlight, and other agents.

Dermal-Of the skin; through or by the skin.

Desiccant-A compound used as a harvest aid that promotes drying of the crop.

Diluent-Any material used to dilute or carry an active ingredient.

Direct supervision-The supervision requirements of a certified pesticide applicator when allowing a noncertified applicator to use Restricted Use Pesticides.

Directed application-A chemical application that is made to a restricted area such as a row, bed, base of plants, etc.

Drench treatment-The application of a liquid chemical to an area until the area is completely soaked.

Drift-Movement of material (e.g., sprays, dusts) outside of the intended area.

Economic poison-Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating andy insects, rodents, nematodes, fungi, weeds or other life forms declared to be a pest. Any substance or mixture of substances intended for use as a plant growth regulator, defoliant, or desiccant.

Economic threshold-The level of a continuing pest infestation where application of a control measure would return more money than the cost of the control procedure.

Efficacy-Effectiveness.

Emulsifier-A chemical which aids in suspending one liquid in another.

Emulsion-A mixture in which one liquid is suspended as tiny drops in another liquid (e.g., oil in water).

Endangered species-A plant or animal species that is determined to be in immediate danger of extinction.

EPA-Environmental Protection Agency, an agency within the Department of Interior responsible for protection of the environment in the United States.

EPCRA-Acronym for the Emergency Planning and Right-to-Know Act, a 1986 law which establishes reporting requirements for hazardous pesticides in storage and those involved in accidental releases.

Eradicant-A pesticide used to eliminate a pest, usually used to describe the activity of certain fungicides.

FDA-Food and Drug Administration

FIFRA-Acronym for the Federal Insecticide, Fungicide, and Rodenticide Act, the fundamental federal legislation (repeatedly amended) regulating pesticide registration and use.

Flowable-A type of formulation that involves finely grinding solid materials with a pesticide and mixing them with a liquid carrier.

Foaming agent-A substance, usually used as an adjuvant, that causes the pesticide mixture to thicken and foam.

Fogger-A type of application equipment that generates very small (aerosol) droplets.

Foliage-The leaves or needles of a plant.

Fumigant-A substance, or mixture of substances, which produce gas, vapor, fume, or smoke intended to destroy insects, bacteria, or rodents. Uses of fumigants are called **fumigation**.

Fungicide-A pesticide used to control fungi.

General Use Pesticide-A pesticide that has not been determined to have undue hazards adn can be purchased and used without certification.

Germination-Process of germinating or beginning of vegetative growth. Often refers to the beginning of growth from a seed. (Note: Many herbicides act by inhibiting germination.)

GPA-Gallons per acre

Gram-The standard unit of weight measure in the metric system. An ounce is equivalent to 28.35 grams.

Granule-A type of pesticide formulation that involves mixing the pesticide with a solid material (clay, grits, etc.) to form a small pellet.

Groundwater-Sources of water that occur underneath the soil surface (in contrast to surface water).

Growth regulator-Organic substances used to promote, inhibit, or otherwise modify the the growth of plants or insects.

Hard water-Water with minerals such as calcium, magnesium, or iron dissolved in it which can cause some pesticide mixtures to curdle and/or lose effectiveness.

Hazard-The probability that injury can result. Regarding pesticide applications, it is a combination of the toxicity of the pesticide and the opportunity for exposure to it.

Hectare-The standard unit of area measure in the metric system. One hectare is equivalent to 2.471 acres.

Herbaceous plant-A plant that does not produce woody tissue.

Herbicide-A pesticide used to kill plants.

Hydrolysis-The splitting or degradation of a chemical by the addition of water.

IGR-Insect growth regulator

Illegal residue-An amount of pesticide that exceeds the legal maximum.

Incompatible-Not capable of being mixed.

Inert ingredient-An ingredient used in formulations of pesticides that, by itself, has no pesticidal action.

Infection-The development and establishment of a plant disease agent (e.g. fungus, bacteria, virus) that causes a disease.

In-furrow-Applied to or in the furrow in which a crop is planted.

Ingestion-To take into the digestive system.

Inhalation-To breathe into the lungs.

Inhibitor-A substance that prevents or suppresses growth.

Inorganic-Chemical that do not include carbon in their chemistry.

Insecticide-A pesticide used to destroy or inhibit the activity of insects.

Instar-the stage of an insect between periods when it sheds its skin (molts).

Integrated Pest Management (IPM)-A philosophy of managing pests that emphasizes use of all appropriate control techniques, in an integrated manner, with an understanding of both the long-term and short-term associated risks and benefits.

Interval-Period of time between two events.

Inversion-A weather condition where temperatures increase with elevation from the ground.

Invert emulsifier-A chemical which allow water to be suspended in an oil mixutre.

Label-When applied to pesticides, the label is the printed material on or attached to the pesticide container.

Labelling-When applied to pesticides, the labelling includes the printed labels plus any associated printed material that refers to or is mentionned on the pesticide label.

Larva-The immature stage of insects that have complete metamorphosis.

Lateral movement-To move horizontally, often applied to certain pesticides or agricultural chemicals which move sideways through the soil.

LC_{50}-The concentration of a substance, such as a pesticide, that is lethal to 50% of the exposed test animals.

LD_{50}-The concentration of a substance, such as a pesticide, that is lethal to 50% of the test animals to which the chemical is applied. Often used as a means to compare the relative toxicity of pesticides.

Leaching-Downward movement of chemicals, usually in association with water.

Lethal-Deadly

Liability-To have legal responsibility for

Metamorphosis-A series of changes in form that occur during the development of insects and many other animals.

Meter-the standard measure for distance in the metric system; equivalent to 39.37 inches.

mg-milligram (1/1000th of a gram)

Miticide-A pesticide used to control mites; an acaricide

Mode of action-The means that a pesticide involves to kill the pest.

Molluscicide-A pesticide used to kill mollusks such as slugs or snails.

Molt-The process of shedding the external covering (exoskeleton) and forming a new covering that is involved in the growth of insects and other organisms.

Mutagen-A substance capable of causing changes in the genes.

Mycelium-A mass of thread-like elements that is produced by many fungi.

Mycoplasma (or mycoplasma-like organism)-A type of organism that resembles bacteria but does not have a cell wall. Several mycoplasmas cause plant disease, such as pear decline and aster yellows.

Natural control-The naturally occuring factors which affect a population. These include naturally occurring biological controls, host plant factors plus various abiotic controls such as weather.

Nematicide-A pesticide used to control nematodes.

Non-labelled-As applied to pesticides, a use that is not included on the label instructions and is not legal.

Non-point source-As applied to pollution, a source of pollutants that is generally distributed and which moves to a another location causing pollution.

Non-selective-Has effects against a broad spectrum of organisms (e.g. plants, animals, etc.).

Non-target organism-An animal, plant, or other organism that may be indirectly affected by a pesticide applications made for control of a pest species.

Noxious weed-A weed species that is defined, by law, as being especially undesirable.

Nymph-The immature stage of insects that have a gradual or incomplete type of metamorphosis.

Oncogen-A substance that has the ability to cause formation of tumors.

Organic compounds-Chemical substances that contain carbon.

Original container-The container which the seller supplied at the point of sale and which contains the manufacturers instructions for use.

Ovicide-A pesticide with the ability to kill the gg stage of insect and mite pests.

Parasite-A living organism that develops in or on another organism (host) causing damage to the organism on which it lives.

Pathogen-A microorganism that causes disease in another organism.

Penetrant-As applied to pesticides, a substance that enhances the ability of the pesticide to penetrate the surface protective coverings of the pest.

Perennial-To have a life cycle that occurs over the course of several years.

Pest-By law, forms of plant and animal life and viruses that cause injuries to plants, man, domestic animals, other organisms or other substances and articles of value to humans.

Pesticide-"Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, or weeds, or any other forms of life declared to be pests; and any substances intended for use as a plant regulator, defoliant or desiccant" (definition in FIFRA).

Pesticide resistance-Development of an ability by a pest to suppress or mitigate the effects of a pesticide that formerly was effective for controlling the pest.

Pest resurgence-A large increase in a pest population following the use of pesticide; usually the result of detrimental effects of a pesticide application on biological control organisms.

pH-The standard measure of acidity/alkalinity; based on a 0-14 logarithmic scale of hydrogen-ion percentage: 7 is neutral, values below 7 are acidic and values above 7 are alkaline.

Pheromones-Chemcials used by an organism to comunicate with other members of the same species.

Photodecomposition-Decomposition of a chemical by light, usually due to ultraviolet radiation.

Photosynthesis-The process of manufacturing simple sugars using the light energy. Typically photosynthesis is used by plants containing chlorophyll to produce food energy.

Phytotoxic-Capable of causing injury to plants.

Post-emergence-After the emergence of a plant through the soil surface.

ppm-parts per million

Pre-emergence-Before the germination and emergence of a plant through the soil surface.

Pre-harvest interval-The period that legally must elapse between the last application of a pesticide and harvest of a pesticide treated commodity.

Private applicator-A person who uses, or supervises the use of, restricted use pesticides on land owned or rented by him or his employer.

Reentry interval-The period which must legally pass between the application of a pesticide and the entering of the field by humans. Reentry intervals may vary depending on protective equipment or other precautions used by indivduals entering treated fields.

Registered pesticide-A pesticide that has been approved for use by the U.S. Environmental Protection Agency for uses that are listed on the pesticide label.

Repellent-A compound which causes avoidance of a treated area by a visiting animal.

Restricted Use pesticide-A pesticide that has been classified as having sufficient hazard to require that its use be only by persons that have passed certification requirements.

Rodenticide-A substance used to kill or repell the activities of rodents.

Scientific name-A name that is given to all species and is recognized as the single name throughout the world for the species. It is express as a two-part name (genus, species).

Secondary pests-Pest species which become important only after the use of a pest management practice (such as use of pesticides) that is directed against another pest species.

Seed treatment-The application of a pesticide to seed.

Selective pesticide-A pesticide that has activity that is limited to only a few species.

Signal word-The word or words that appear on all pesticide labels to indicate the relative toxicity or hazard of the product (Danger-Poison, Warning, Caution).

Soil incorporation-Mechanical mixing of a pesticide with the soil.

Soil sterilant-An herbicide that is capable of killing all plant species that grow on areas treated with the herbicide.

Solubility-The ability of a chemical to dissolve in another chemical or solvent; a measure of the amount of substance that will dissolve in a given amount of another substance.

Soluble powder-A powder formulation of a pesticide that dissolves and forms a solution when mixed with water.

Spores-The primary stage by which fungi reproduce and disperse.

Surfactant (surface-active ingredient)-A chemical substance that breaks the surface tension between substances of different compostion.

Suspension-Dispersal of very finely divided particle in a liquid

Synergist-A substance that, when mixed with a pesticide, greatly increases the activity of the pesticide. A synergist may or may not have pesticidal activity of its own.

Systemic pesticide-A pesticide that has the ability to move through the plant or animal to which it is applied.

Tank mix-The mixture of two or more chemicals, including pesticides, in a spray tank.

Technical material-The form of a purified pesticide as it is originally manufactured and before it is mixed with other ingredients during formulation.

Teratogen-A compound that is capable of causing birth defects.

Threatened species-A species whose populations have currently been reduced to such low levels that, without adequate protective measures, will become endangered with extreme threat of extinction.

Tolerance-As applied to pesticide law, a maximum amount of a pesticide that can appear on agricultural produce that can be sold in commmerce.

Toxic-Poisonous

Treated area-The area that is defined to be involved during application of a pesticide.

USDA-United States Department of Agriculture

Vapor pressure-The property which causes a chemical compound to evaporate. The lower the vapor pressure, the more volatile the compound.

Vector-An organism that transmits a disease producing agent from one host to another.

Viscosity-A property of liquids that determines how readily they resist flow.

Volatility-The ability of a compound to evaporate.

Wettable powder-A pesticide formulation that involves incorporation of the pesticide with a solid material. When mixed with water and agitated the formulation forms a suspension.

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